

U.S. Bureau of Naval Personnel

# Hand Tools



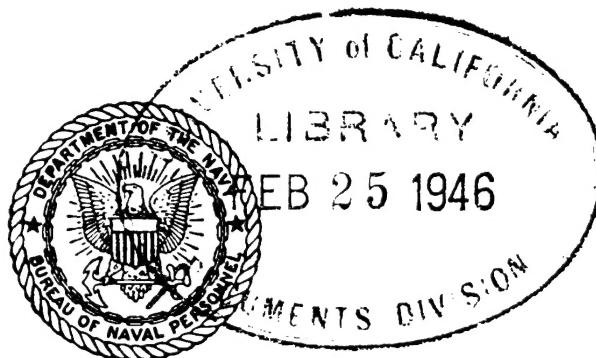
RESTRICTED

NAVY TRAINING COURSES



# HAND TOOLS

PREPARED BY  
STANDARDS AND CURRICULUM DIVISION  
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## PREFACE

This book was written for the enlisted men of Naval Aviation. It is one of a series of books designed to give them the information necessary to perform their aviation duties.

Familiarity with hand tools and how to use them is of primary importance to aviation technicians of all rates, for even the most simple routine jobs require the use of tools. Tools, in fact, are indispensable in the maintenance of airplanes, and an aviation specialist—whether he is concerned with radio, electricity, metal work, airplane structures, power plants, or ordnance—cannot get along without calling upon them daily for assistance.

In this book, hand tools are arranged in groups according to the kinds of work they are designed to perform. The book begins with advice on the handling and care of such general purpose tools as hammers, screw drivers, pliers, wrenches, and punches. It explains the use of shaping and cutting tools—chisels, hacksaws, files, and hand snips. And the information about the tools used for soldering, drilling, reaming, thread cutting, tube fabrication, and for making measurements is followed by a discussion of abrasives, which are important adjuncts to hand tools.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the Naval Air Technical Training Command and the Training Division of the Bureau of Naval Personnel.

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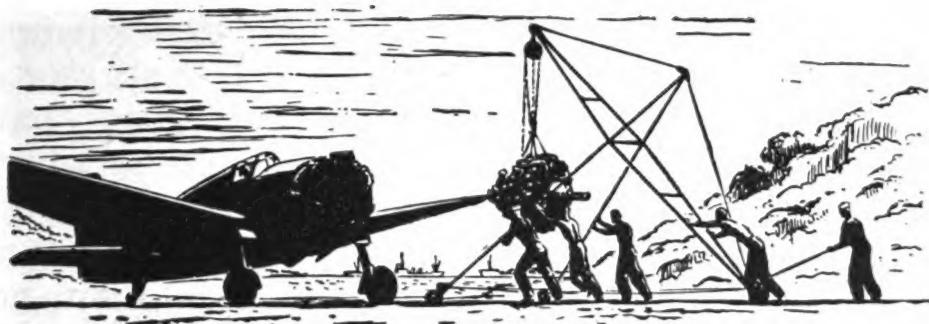
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# HAND TOOLS





## CHAPTER I

### GENERAL PURPOSE TOOLS FIGHTING TOOLS

The Unit landed at Guadalcanal and went inland to an advance base. In the Unit were aviation technicians—machinist's mates, metalsmiths, radio-men, electrician's mates—men who knew airplanes and knew how to use the tools to service them. Their job was to overhaul, inspect, and repair the airplanes of Squadron X. And how they did it, without the customary tools, is one of those stories of valor and sheer guts that is typical of the victory on Guadalcanal.

When they got there, tools had not arrived but there WERE jeeps. And under the jeep seats were a few tools—monkey wrenches, ball pien hammers, screw drivers, slip pliers, and several other odd items. With these simple tools, the men kept the airplanes of Squadron X in the air, and later they did the same job for a second squadron.

They did engine checks in a day. Once they changed engines on a Marine B24 that had made an emergency landing on their field. For months, they were putting together planes, radio equipment, and ordnance gear with the tools from under the seat of a jeep!

Just once did they know defeat, but then only momentarily. The spring in the electric starter of one of the airplanes broke. They had no spare parts. So they took the mainspring from an alarm clock and made a new starter. It worked! They improvised and they cussed but they worked carefully and hard. There were neither men nor airplanes lost because of mistakes made by that ground crew. **THEY DIDN'T MAKE MISTAKES.**

They knew how to use tools so well that they could seemingly achieve miracles with the few in their possession. The tools of aviation technicians are fighting tools. To carry your own weight in this war, you'd better be sure that **YOU KNOW HOW TO USE THEM.**

### **YOU DON'T MAKE MISTAKES**

If you think that you have pinched the tube getting a tire on an automobile, oftentimes you can shrug your shoulders and let it go. **NOT IN AVIATION.** If you think you've pinched the tube on an airplane tire, you take it off and check it to make sure. You don't make mistakes in Naval Aviation.

You won't know all the answers when you join a unit, but you have a good opportunity to learn. If you don't know the answer, start asking questions or get the help of a more experienced technician. Suppose you neglect to tighten a spark plug in an airplane. When that plane is flying along in formation, it will shortly begin to whistle like a squadron of peanut machines, and will be forced back to the base.

### **KNOW THE RULES**

Tools need a lot of care and they can't take rough handling. Remember, when you are in a combat zone, there is a limited supply of tools. You won't

get any more than your original issue and if you break one of them, it will be a long, long time before you get a replacement.

There are a few rules to follow that will make your tools last longer and keep them in better condition. Put those tools not in actual use in a safe place while you are working. If tools fall on the ground, they may break. Whenever you work on a PBY or a PBM, secure the tools to your wrist to prevent them from falling overboard.

**PUT TOOLS AWAY WHEN YOU ARE THROUGH WITH THEM.** If you leave them lying around, you can easily trip over them, spraining or perhaps breaking your ankle.

To save time and avoid needless waste, assign each tool to a place in your workbox and see to it that each tool is kept in its place. Before putting them in the box, check them for dirt or rust. If you find evidence of either, clean them and give them a coating of light oil. Dirt and rust are vicious enemies of all tools.



Figure 1.—Invitation to a field day.

The workbench that looks like an assorted junk heap in figure 1 is an invitation to a field day. It's impossible to do good work when tools are misused

and mislaid. Another bad practice is leaving sharp tools protruding from workbenches. They will tear, rip, or puncture any moving object that comes in contact with them, INCLUDING YOU. For the same reason, don't carry sharp tools in your back pocket.



Figure 2.—Using the wrong tool ruins the tool.

Most tools can perform several jobs. But plain common sense will tell you—and figure 2 will show you—that you can't use a tool on a job for which it was not designed. The hammer, for instance, is a striking tool whereas the screw driver is designed to loosen and tighten screws. If you use a screw driver when you should be using a pry bar, the screw driver may bend or snap in two. Where tools are concerned, you can't do a good job the wrong way.

**FOLLOW THE RULES.** Tools are indispensable servants, performing innumerable tasks beyond the power of your own hands.

## HAMMERS

Whoever thought to crack a nut with a stone was unknowingly inventing a tool. When a later genius tied a handle to the stone he made the first hammer.

The hammer is a very simple striking tool. It is just a weighted head and something to direct its course. Your tool kit is not complete unless it contains at least two or three types of hammers. The most useful hard-face hammer is the ball pien, or as it is sometimes called, the machinist's hammer. Ball pien hammers (the older spelling of the word is PEEN), such as the one shown in figure 3, are made with hardened steel faces and fitted with a stout handle of hickory or other hardwood.

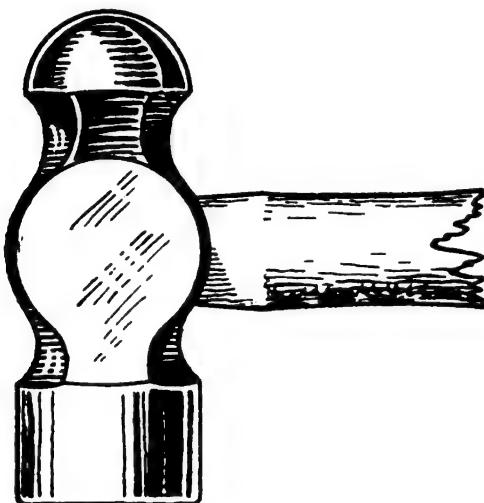


Figure 3.—Ball pien hammer.

The flat portion of the head, used for most hammering, is called the FACE and the other end the PIEN. The hole for the handle is the EYE. Ball pien hammers are classed according to the weight of the head without the handle. The three most popular sizes are the 6-ounce for light work, the 12-ounce for general utility, and the 16-ounce for heavy work.

Aircraft metals are soft. Therefore you must use hammers sparingly on all aircraft metal work. If you pound soft metal with a hard-face hammer, you will dent the material and cause extra work for yourself. Use soft-face hammers whenever you want to avoid scarring or denting the material.



Figure 4.—Don't pound on soft metal.

Soft-face hammers have faces of wood, rawhide, plastic, babbitt, copper, and pyralin. As a general rule, wood does not make a satisfactory soft-face hammer as the wood is likely to splinter. A closely wound rawhide mallet is very satisfactory. This tool will stand a surprising amount of abuse. Do not use it on objects of small diameter, such as bolts and punches, as they will destroy the surface of the face.

A more elaborate soft-face hammer is shown in figure 5. A feature of this tool is replaceable tips which are clamped in the head of the hammer. The tips may be of rawhide, babbitt, or copper.

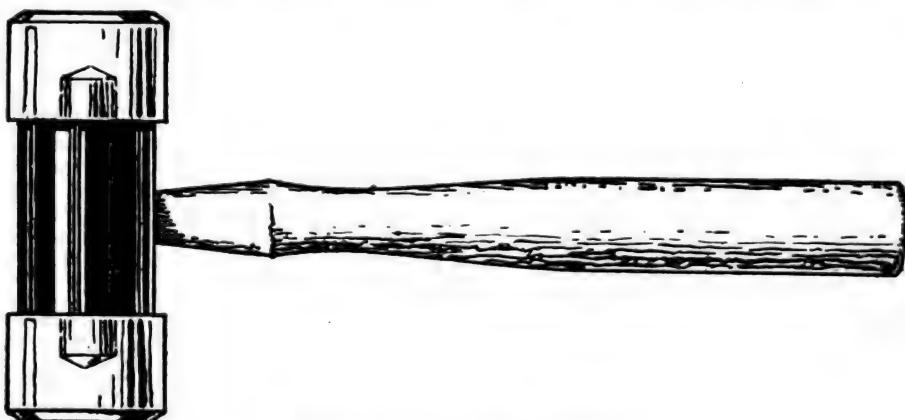


Figure 5.—Soft-face hammer.

The **MALLET** is a hammerlike tool made of hickory, rawhide, or rubber, and is used for pounding down seams and forming sheets over stakes. The mallet will not dent or mar the metal as will a steel hammer.

You know what happens when you hold a baseball bat too close to the head. It reduces the power of the swing. When you "CHOKE" a hammer, the same thing happens. It reduces the force of the blow and makes it harder to hold the hammer head in an upright position. When you want to strike a heavy blow, grip the handle close to the end. This increases the length of the lever arm and



Figure 6.—A little care goes a long way.

makes the blow more effective. Whenever possible, strike the object with the full face of the hammer and with the face parallel to the work. This distributes the force of the blow over the entire hammer face and avoids damaging its edge.

The hammer handle always should be tight in the head. Never work with a hammer having a loose head. This is dangerous because the head may fly off and cause an injury. Figure 6 is an illustration of a common accident that you can avoid by exercising a little care.

The eye or hole in the hammer head is made with a slight taper in both directions from the center.

After the handle is inserted in the head, a steel wedge is driven into the end of the handle. This expands it in the opposite taper in the eye and thus the handle is wedged in both directions. If the wedge starts to come out, it should be driven in again to tighten the handle. If the wedge comes out and is lost, replace it before continuing to use the hammer.

Don't use the end of the hammer handle for bumping purposes. It will split and ruin the handle. And never use the handle for prying. It is easily broken that way. Keep your hammers clean—every now and then give them a coating of light oil.

## SCREW DRIVERS

Screw drivers have one main purpose in life—to loosen or tighten screws. However, they have been used as a substitute for everything from an ice pick to a bottle opener.

There are three main parts to a screw driver. The portion that you grip is called the HANDLE, the steel portion extending from the handle is the SHANK, and the end which fits into the slot of the screw is called the BLADE. See figure 7. The slim steel shank is designed to withstand consider-



Figure 7.—Parts of a screw driver.

able twisting force in proportion to its size but it will bend or crack in two if it is used as a pry or a pinch bar.

Another thing which may happen if the screw driver is used for prying—THE BLADE MAY BREAK. The tip of the blade is hardened to keep it from

wearing, and the harder it is, the easier it will break if much of a bending strain is applied. If the shank of the screw driver is once bent, it usually is difficult to get it perfectly straight again. And if the shank is not straight, it is hard to keep the blade centered in the slot of the screw.



Figure 8.—Reading from either side: The wrong tool is being used.

Figure 8 contains two good illustrations of bad practices. Don't hammer on the end of a screw driver. It is not to be used in place of a cold chisel, a punch, or a drift. Hammering can break the shank, mushroom the end of the handle, or snap off the blade.

Before you do any tapping on the handle, see that you have a screw driver which has a steel shank extending through the handle. Screw drivers which do not have the shank extending through the handle have the handle pinned to the shank, usually through the ferrule which is the metal sleeve on the handle where the shank enters. If you attempt to hammer on a screw driver of this type, chances are the handle will slip and the screw driver will be ruined.

The most common types of screw drivers are standard, offset, and ratchet shown in figure 9.

The STANDARD SCREW DRIVER is used for most ordinary work and comes in a variety of sizes. Too much emphasis cannot be placed on selecting the correct size of screw driver so that the thickness of the blade makes a good fit in the screw slot. This not only prevents the screw slot from becoming burred and the blade tip from being damaged, but reduces the force required to keep the screw driver in the slot.

### GRINDING THE BLADE

The tip of the screw driver blade should be ground so that the sides of the blade are practi-

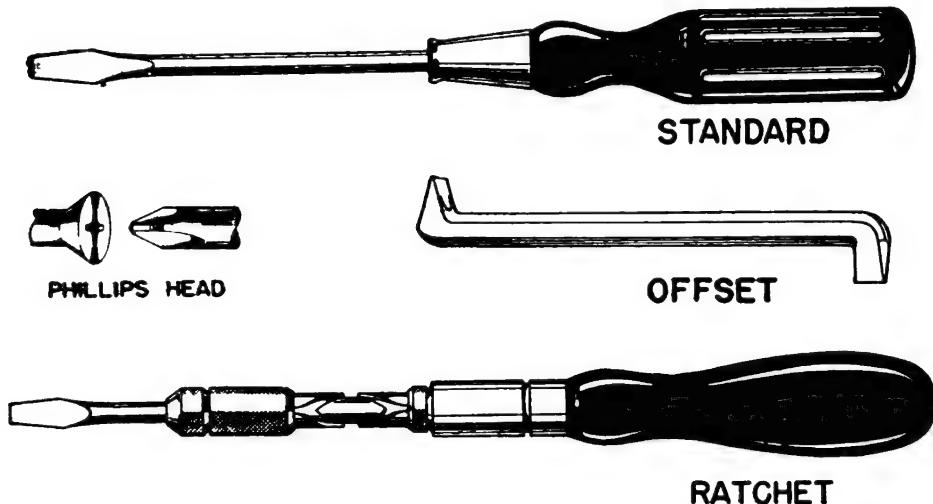


Figure 9.—Types of screw drivers.

cally parallel, and the blade sides should gradually taper out to the shank body. If you ever damage the end of the blade, make it serviceable again by grinding it against an emery wheel. First grind the tip straight and at a right angle to the shank. After the tip is ground, square dress off from each face, a little at a time. Keep the faces parallel for a short distance or have them taper in a slight amount. Never grind the faces so that they taper to a sharp edge at the tip. See figure 10 for a correctly ground tip.

There is a heavy duty screw driver with a square shank. It's designed that way so you can use a wrench on it. The shank is extra large, made strong enough to TAKE IT, and it's the only type of

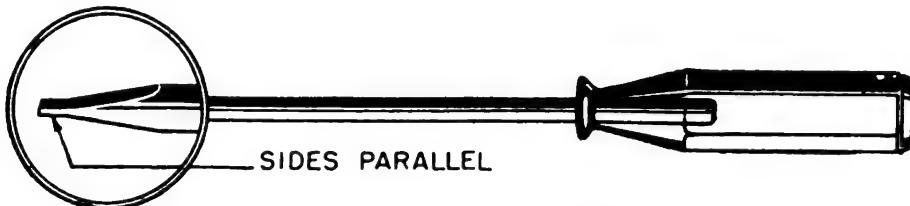


Figure 10.—Correctly ground tip.

screw driver on which you should use a wrench. DON'T USE PLIERS ON A SCREW DRIVER.

In addition to the set of general purpose screw-drivers, there are other types designed for electrical and instrument work. One of these is a small screw driver with a clip which you may fasten to your pocket.

The OFFSET SCREW DRIVER is a handy tool in tight corners. It has one blade forged in line with the shank or handle and the other blade at right angles to the shank. With such an arrangement, when the swinging space for the screw driver is limited, you can change ends after each swing and thus work the screw in or out of the threaded hole. Use this screw driver when there isn't sufficient space to work a standard screw driver.

The PHILLIPS type screw driver is made with a specially shaped blade that fits Phillips cross slot screws. The heads of these screws have two slots that cross in the center. This checks the tendency of some screw drivers to slide out of the slot onto the finished surface of the work. The Phillips screw driver will not slip and burr the end of the screw if the proper size is selected.

A word of caution—never use a screw driver to check an electrical circuit where the amperage is high. The electrical current may be strong enough to arc and melt the screw driver blade.

It is dangerous to hold work in your hand while tightening or loosening a screw. If the blade slips, it can cause a bad cut. It is better to put the work in a vise or on a solid surface that will bear the pressure of the driver.

## PLIERS

There are many types of pliers. Those used most frequently are shown in figure 11.

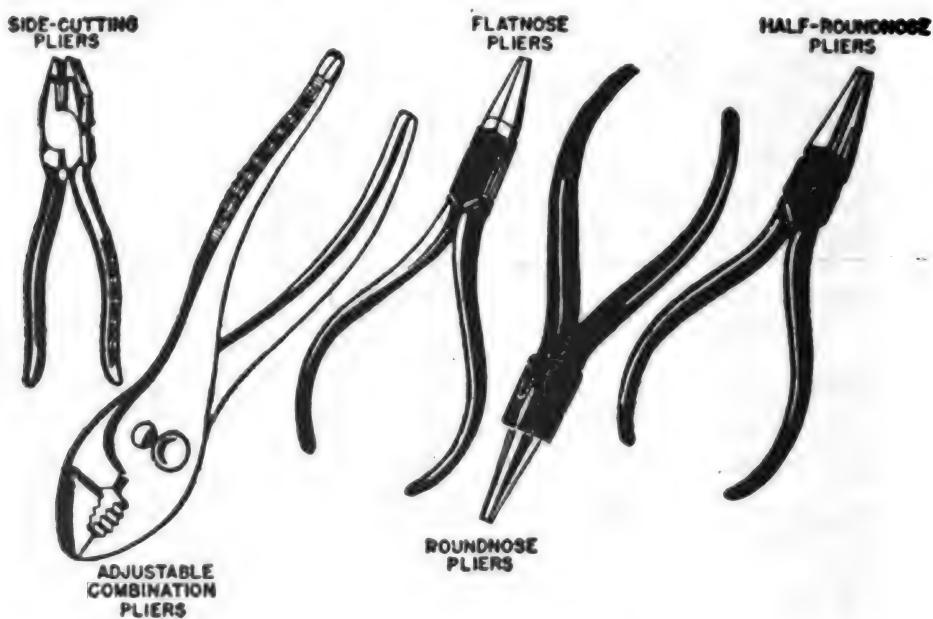


Figure 11.—Types of pliers.

The pliers most commonly used in aviation work are the 6-inch combination slip joint pliers usually called COMBINATION PLIERS. The slip joint permits the jaws to be opened wider at the hinge for gripping large diameters. Combination pliers come in sizes from 5 to 10 inches. This is a measure for their overall length. In addition to the 6-inch size, it's a good idea to have 5-inch pliers for light work and 10-inch pliers for heavy work. The better grades of combination pliers are drop forged steel and withstand hard usage.

These adjustable combination pliers are used principally for holding and bending flat or round stock. The various lengths and shapes of flat-nose, roundnose, and half-roundnose pliers make it possible to bend or form metal into a variety of shapes. Many special-purpose pliers are available for specific jobs.

Avoid using pliers on a hardened surface as this dulls the teeth and causes pliers to **LOSE THEIR GRIP**.

Beginners oftentimes use pliers for loosening or tightening nuts. Pliers damage the "flats" of the nut. **USE WRENCHES ON NUTS—NEVER PLIERS.** Mark that down—"USE WRENCHES ON NUTS—NEVER PLIERS." One thing more, pliers are made in a wide range of sizes to avoid overstraining and perhaps breaking. Make sure that you have a tool heavy enough for the job you're doing.

Other pliers which are useful in aviation work are the diagonal cutting pliers, usually referred to as **DIAGONALS**. The diagonal is a short-jawed cutter with blades at a slight angle, as you will note by glancing at figure 12. You can use this tool to cut soft wire, and you will find that it is practically indispensable in removing or applying safety wire. Because the cutting jaws are at an angle, these pliers are ideal for removing and replacing cotter pins. Diagonal pliers can nip cotter pins to the desired length and spread the ends of the pin after it is put in the hole.

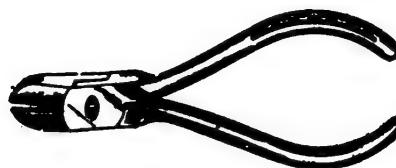


Figure 12.—Diagonal cutters.

Always get the right tool for the right job. Diagonal cutters have been used for a great many

purposes for which they were not designed. They have been used to cut insulation from electrical cables, to cut plywood, and to serve as tin snips. They are sturdy tools and will give long service if they are NOT used for jobs that will damage the cutting edges. Don't cut spring steel wire or hard rivets with them. When you are cutting the largest material within the capacity of a diagonal, use the back of the jaw and not the point. This reduces the tendency to spring the jaws. Once the jaws are sprung it is difficult, if not impossible, to cut fine wire.

Long nose pliers, either the flat nose or duck-bill type, will help you out of such tight spots as recovering a washer or a nut which gets into a place where it is hard to reach. Long nose pliers make it easier to remove and install valve spring retainer pins used on some engines.

If you do considerable electrical work, you will also want a pair of 5- or 6-inch regular side cutting pliers for cutting primary and high tension ignition wire and making other wire replacements in the electrical system.

Pliers, of course, should be kept clean. Every now and then, wash off the dirt and grit and put a drop of oil on the joint pin. Simple precautions like these will cut down wear and prevent rusting. Rust, by the way, is Public Enemy No. 1, as far as all tools are concerned. Also, if tools are dirty, greasy, or oily, they can slip and skin your knuckles, or cut scratches in finished work.



## CHAPTER 2

### MORE GENERAL PURPOSE TOOLS

#### WRENCHES

Fundamentally, the wrench is an instrument for exerting a twisting strain, as in turning bolts and nuts. The majority of nuts and bolt heads are six-sided. The wrench is designed to grip opposite sides of these nuts or heads when you are removing or replacing parts.

Wrenches used in aviation work do not differ greatly from those used in other trades, except that whenever possible they are smaller and lighter. In order to get a "flyweight" or a "light-weight" wrench WITH STRENGTH, it is necessary to use a better grade of steel. One of the most popular materials for aircraft wrenches is chrome-

vanadium steel. Wrenches made of this material are almost unbreakable. It is practically impossible to spring the jaws. Some of these wrenches are unconditionally guaranteed against destruction.

### OPEN-END WRENCHES

Solid, nonadjustable wrenches with openings in each end are called open-end wrenches. In an average set there are about 10 wrenches with openings that range from  $\frac{5}{16}$  to 1 inch in width. Figure 13 shows an average set of open-end wrenches.

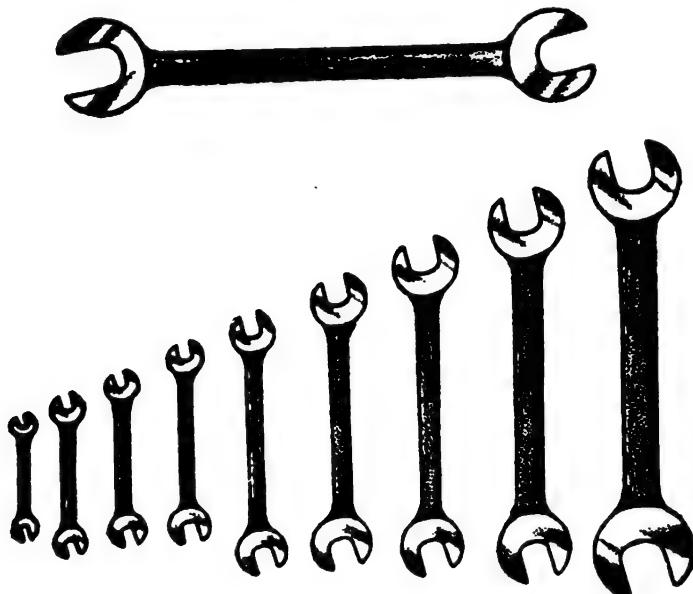


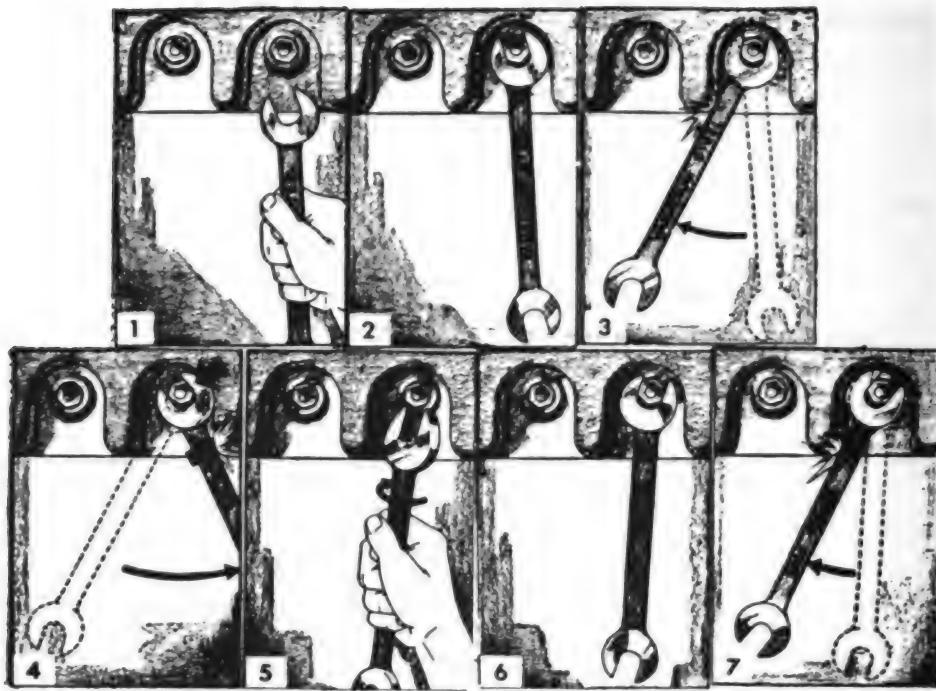
Figure 13.—Set of open-end wrenches.

The size of the openings between the jaws determines the size of the wrench. The smallest wrench in the ordinary set has a  $\frac{5}{16}$ -inch opening in one end and a  $\frac{3}{8}$ -inch in the other. That is why it is called a  $\frac{5}{16} \times \frac{3}{8}$  open-end wrench. These figures refer to the distance between the flats of the bolt head or the nut and not to the bolt diameter. You will discover, if you take the time to measure them, that the openings actually measure from 5 to 15 thou-

sandths of an inch larger than the sizes marked on the wrenches. This difference makes it much easier for you to slip wrenches onto bolt heads or nuts.

The smaller the openings in the wrench, the shorter its overall length will be. This proportions the lever advantage of the wrench to the size of the bolt or stud. With a given amount of pull on a wrench, a short one will produce less twisting effort on the nut than a longer one. It's a good idea to have wrenches made this way. You are very apt to apply too much pulling force on wrenches. When you do this, you can either strip the threads or twist the nut or bolt in two. The well-proportioned wrench won't allow you to apply as much force as you'd like to. Wrenches with larger openings are made proportionately longer to increase the lever advantage. And they are made heavier to provide the required strength.

The wrenches shown in figure 13 have their jaws at an angle of  $15^\circ$ , which is about average, to the handle. Some are made with a greater or smaller angle. One popular type, the right angle wrench, has its jaw openings at  $90^\circ$  to the handle. The reason why wrenches are that way will be obvious to you when you work in CLOSE QUARTERS. Suppose you are loosening a nut where there is very little space in which to swing a wrench. You will find that by FLOPPING the wrench—turning it over so that the other face is down after each stroke—the angle of the head will be reversed and will fit the next two flats on the hexagonal (six-sided) nut. The  $15^\circ$  angle jaw and the FLOPPING trick enable you to turn a hexagonal nut continuously when the swing of the wrench is limited to  $30^\circ$ . Glance at figure 14 for the FLOPPING procedure.



**Figure 14.**—How a wrench, with its head at a 15-degree angle to the body, can be used to turn a nut when the "swing space" is limited to 30 degrees:

1. Wrench, with opening sloping to the left, about to be placed on nut.
2. Wrench positioned and ready to tighten nut. Note that space for swinging the wrench is limited.
3. Wrench has been moved clockwise to tighten the nut and now strikes the casting, which prevents further movement.
4. Wrench is removed from nut and turned counterclockwise to be placed on the next set of flats on nut. But corner of casting prevents wrench from fitting onto the nut.
5. Wrench is being flopped over so that wrench opening will slope to the right.
6. In this flopped position the wrench will fit the next two flats on the nut.
7. Wrench now is pulled clockwise to further tighten nut until wrench again strikes casting. By repeating the flopping procedure, the nut can be turned until it is tight.

There are special open-end wrenches, such as tappet wrenches, which are thin and have extra long handles that enable you to adjust valves.

The correct use of open-end wrenches is explained in a few simple rules. First and most important, be sure that the wrench **FITS** the nut or bolt head.

When you have to pull hard on a wrench, as in loosening a tight nut, make sure the wrench seats squarely on the sides of the nut. **PULL** on the

wrench—DON'T PUSH. Pushing on a wrench is dangerous. Supposing you push on a wrench to loosen a tight nut and the nut breaks loose unexpectedly. You will invariably strike your knuckles against some part you overlooked and knock skin from your hands. If an incident ever occurs where it is impossible for you to do anything but push on the wrench, use the base of your palm and hold your hand open. This will save your knuckles. When you cut yourself or bang your knuckles, 9 times out of 10 you were just plain careless and 10 times out of 10 there isn't any excuse for it.

Only actual practice will tell you if you are using enough or too much force on wrenches. The best way to tighten a nut is to turn it until the wrench has a firm, solid "feel." This will set up the nut to its final position without twisting off the bolt or stripping the threads in the nut. Experience alone will develop this sense of "feel" which will enable you to know whether a nut or cap-screw is tightened to the proper degree. Practice until you KNOW you've got it.

#### ADJUSTABLE WRENCHES

Adjustable wrenches are shaped somewhat similarly to open-end wrenches. The big difference, as you can see in figure 15, is that one jaw is adjustable. The angle of the opening to the handle on an adjustable wrench is  $22\frac{1}{2}$  degrees. It has a spiral screw-worm adjustment in the handle. The width of the jaws may be varied from 0 to  $\frac{1}{2}$  inch or more. This tool has smooth jaws, and is designed as an open-end wrench. It is an especially good emergency tool, since one adjustable wrench can be made to serve for several open-end wrenches.

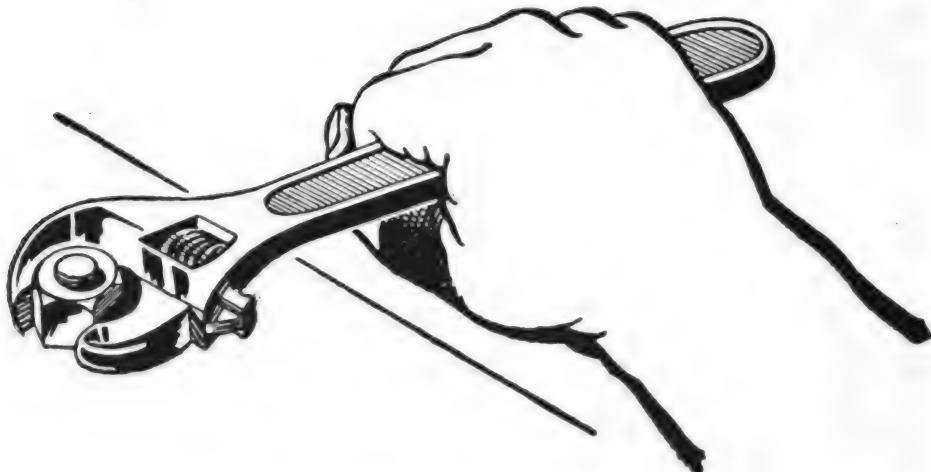


Figure 15.—Adjustable wrench.

Although adjustable wrenches are convenient at times, they are not intended to take the place of standard open-end wrenches, box wrenches, or socket wrenches. Smaller adjustable wrenches are principally used when you find an odd size nut or bolt that one of your open-end wrenches or socket wrenches won't fit.

Adjustable wrenches aren't intended for hard service—TREAT THEM GENTLY. They will not stand excessive strain especially at the wide open position. Whenever you have to exert any amount of force on an adjustable wrench to "break loose" a tight nut or "snug down" a nut which is being tightened, there are two important points to remember. FIRST, ALWAYS PLACE THE WRENCH ON THE NUT SO THAT THE PULLING FORCE IS APPLIED TO THE STATIONARY JAW SIDE OF THE HANDLE. Adjustable wrenches can withstand the greatest force when used in this manner. Then, after placing the wrench on the nut, tighten the adjusting knurl so the wrench fits the nut snugly. If these precautions are not observed, the life of an adjustable wrench will be short.

Keep wrenches clean with a coating of light oil. Apply oil to the knurl and the sides of the adjust-

able jaw where it slides in the body. Inspect them every now and then for cracked knurls or jaws.

### BOX WRENCHES

Box wrenches are popular tools. Their popularity is partly based on their ability to operate in close quarters. They are called "box" wrenches because they box or completely surround the nut or bolt head. In place of a hexagon or six-sided opening, there are 12 notches arranged in a circle. See figure 16.

A wrench with this type opening is called a 12-point wrench. A 12-point wrench can be used to continuously loosen or tighten a nut with a mini-



Figure 16.—Box wrench.

mum swing of the handle of only 15 degrees compared to a 60-degree swing of the standard open-end wrench, or to a 30-degree swing of the open-end wrench if it is flopped after every swing.

**MAJOR ADVANTAGES OF THE BOX WRENCH**—there is no chance of the wrench slipping off the nut and it can't spread on the nut. Because the sides of the opening in a box wrench are so thin, it is ideally suited for nuts which are hard to get at with an open-end wrench. Figure 18 will give you an idea of a typical set of box wrenches.

In addition to the regular box wrenches with straight handles, some have their heads set at an angle of 15 degrees to the handle. This tips upward the end of the wrench which is not on the nut and provides clearance for your hand.

Box wrenches are often made with an offset of either one or both ends. Again, the purpose of these designs is to provide clearance for your hand.

There is one disadvantage to using box wrenches. While they are ideal to "break loose" tight nuts or to pull tight nuts tighter, you lose time when you use a box wrench to turn the nut off the bolt once the nut is broken loose. You must lift a box wrench completely off the nut, then place it back on the nut in another position. The only time you can avoid this tedious process is when there is sufficient clearance to spin the wrench in a full circle.



Figure 17.—A combination wrench.

After a tight nut is broken loose, it can be completely backed-off or unscrewed much more quickly with an open-end wrench than with a box wrench. This is the cue for the COMBINATION WRENCH which consists of a box wrench on one end and an open-end wrench on the other. A combination wrench is shown in figure 17.

You can use the box end for "breaking loose" or "snugging down" nuts and the open-end for otherwise turning the nut.

There is a large box wrench for heavy duty work. It is used with an extension handle, which provides

great leverage and permits you to apply all the pressure you wish.

Hammering on wrenches is strictly taboo—with one exception. There is a special type of box wrench, heavy and strongly made so that you can hammer on it. The handle is short and has a pad on which the hammer blows are struck. This box wrench is known as a “slugging” or “striking” wrench.

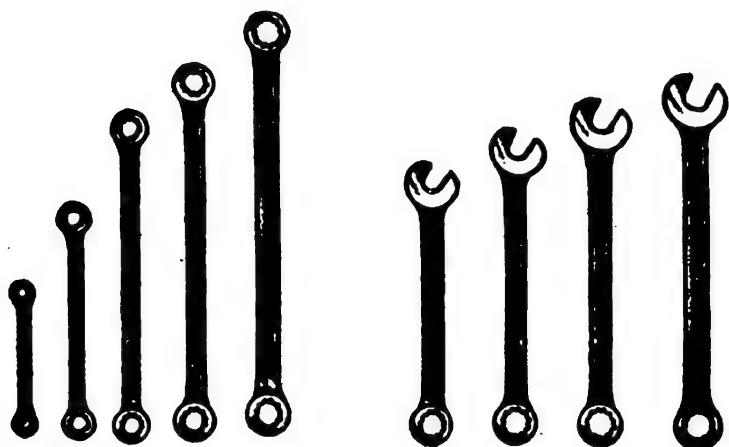


Figure 18.—A set of box and combination wrenches.

### SOCKET WRENCHES

There are many kinds of socket sets used by mechanics. Some of them are illustrated in figure 19. Large combination sets contain heads or sockets to fit all standard nuts from a No. 6 machine screw to a  $\frac{3}{4}$ -inch standard nut. Socket wrenches are made to fit larger nuts. As a rule, they have to be purchased separately. The sockets are usually made with a 12-point opening for the nut on one end and a  $\frac{3}{2}$ -inch or a  $\frac{3}{8}$ -inch square opening on the other end for the handle. There are individual sockets to fit various sizes of square or special nuts, and also with a screw driver blade attachment.

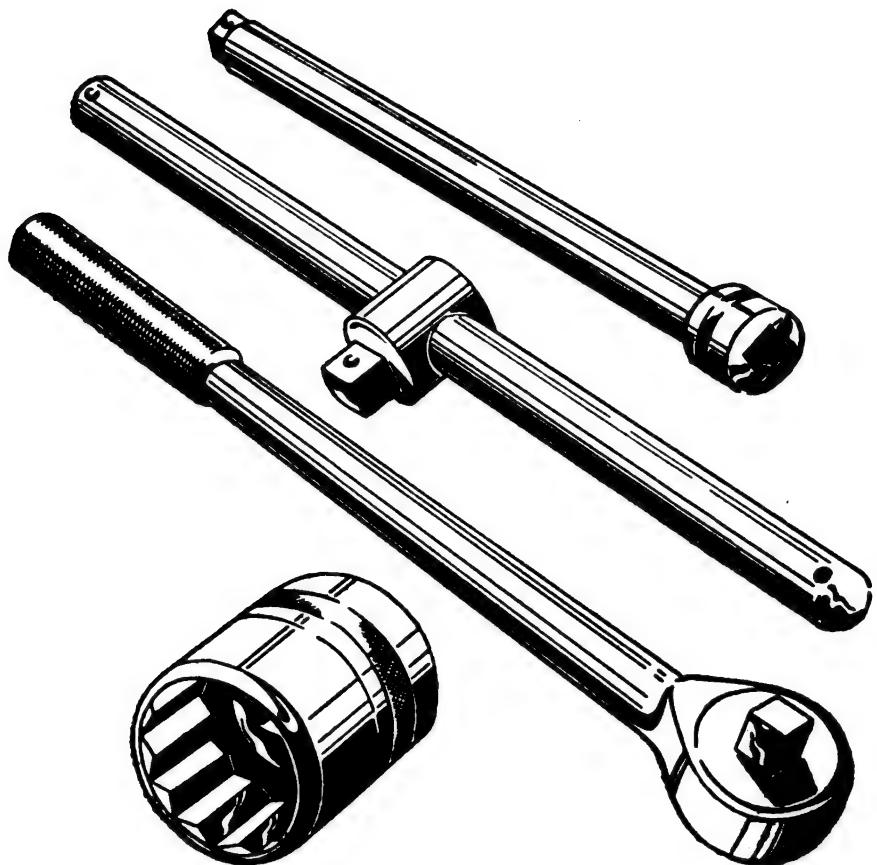


Figure 19.—Socket wrenches.

There are various types of handles, such as the T handle, ratchet handle, screw driver grip handle, and a "speed" handle. The "speed" handle resembles a carpenter's brace. These handles add to the utility and convenience of a socket. With so many accessories available, it is possible to assemble a combination that can do almost any job quickly and easily.

The detachable sockets have been greatly improved over earlier types. The early sockets were large and heavy with thick walls. They had to be made that way to provide sufficient strength to stand the strain. The opening for the nut or bolt head was hexagonal—six sided. They were vastly different in appearance from the present sockets which are made out of high-strength alloy steel and

consequently have both thin walls and STRENGTH. There are many places on an airplane where thin wall sockets are necessary because there is not sufficient clearance for the old heavy wall type.

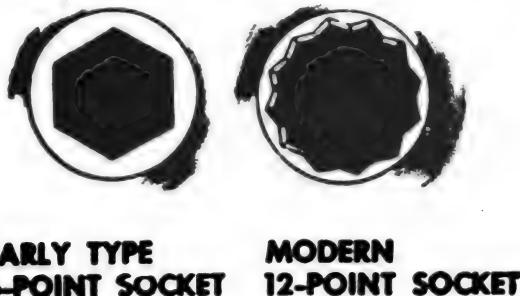


Figure 20.—The old and the new.

You see in figure 20 that the openings in these sockets are formed by a series of notches that have been cut in a circular hole. Because there are 12 of these notches, it is called a 12-point socket. The 12-point socket can be positioned on a nut more quickly than a hexagon-shaped socket because it requires less than  $\frac{1}{12}$  of a turn—usually much less—to fit it onto the nut as compared with about  $\frac{1}{6}$  of a turn for hexagonal sockets.

To use the socket wrench, select the size of socket that fits the nut, engage it on the ratchet handle, and place the socket on the nut. Inside the head of the ratchet handle is a pawl or dog which fits into one or more of the ratchet teeth.

When you pull on the handle in one direction, the dog holds in the ratchet teeth and turns the socket. Move the handle in the other direction and the dog ratchets over the teeth, permitting the handle to be backed up without moving the socket. That's the secret of the ratchet handle's speed—the socket does not have to be raised off the nut to get another "bite."

The handle ratchets in one direction when tightening a nut and in the other direction when

loosening a nut. Usually, a means is provided on the handle for changing the direction of the ratcheting. On some makes, there is a little lever which you can flip to the right to make the head ratchet when the handle is moved in a counter-clockwise direction. This is the way you want it to work when tightening a nut. When loosening a nut, flip the lever to the left and the handle will then ratchet in a clockwise direction.

Modern socket-wrench sets have hit a new high in adaptability. The varied sets of sockets, the ratchet handle, and the NUMEROUS ACCESSORIES make the socket wrench indispensable in repair work.

The hinged offset handle, for instance, is very convenient. To loosen a tight nut, the handle can be swung until it is at a right angle to the socket—thus providing the greatest possible leverage. After you have loosened the nut to the point where it turns easily, you can put the offset handle in the vertical position and twist it with your fingers to completely remove the nut from the bolt or stud.

Besides the hinged offset in the socket wrench set, there is a SLIDING offset handle. Its head can be positioned at the end or at the center of the handle. If you want to do it, you can make a T handle with a sliding offset and an extension bar.

Speed handles, sometimes called "speeders" or "spinners" are convenient for such jobs as speeding up work when there are many nuts to remove. The speed handle is worked like a brace, which the woodworker uses with a bit to bore holes. A speed wrench will get cylinder head nuts off in a hurry after they have been broken loose with the sliding offset or the ratchet handle.

A universal joint frequently comes in handy when working nuts in those places where a straight wrench cannot be used. The universal joint en-

ables you to work the wrench handle at an angle with the socket. Often this is a big help when working in close places.

Large socket-wrench sets also contain about 5 extra deep sockets for use on spark plugs and on nuts which are a long way down on the bolt, such as on U bolts.

Another accessory for the socket-wrench set is a handle which measures the amount of pull you put on the wrench. This wrench, shown in figure

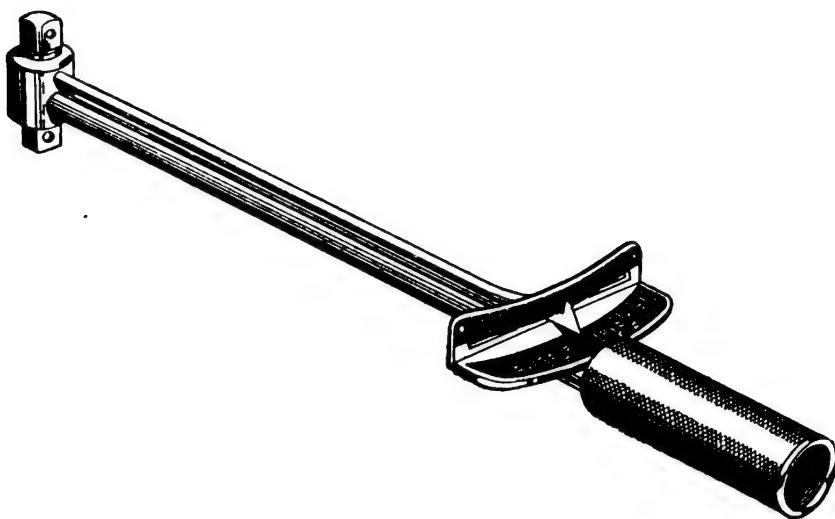


Figure 21.—A torque wrench.

21, is called a “torque wrench.” Torque is the amount of turning or twisting force applied on the nut. And a torque wrench tells you just how much of that turning or twisting force you are applying.

On some makes of torque wrenches, a pointer indicates the amount of applied force on a scale. On others, you can set the dial for the exact amount of torque you want to apply. Then, when you pull on the wrench, a light flashes the instant you hit the prescribed amount.

The accuracy of torque measuring depends on how accurately the threads are cut, the amount of lubrication applied to the threads, and the type of lubrication. Readings shown by the torque wrench are much more accurate when the threads are lubricated. Therefore, threads in cylinder head nuts or stud nuts should always be lubricated before you try to replace or tighten them.

All the better socket-wrench sets are made of high quality materials. If you do not misuse them, they can be depended upon to give long service. The important thing to remember is that the sockets and handles should never be overstressed.

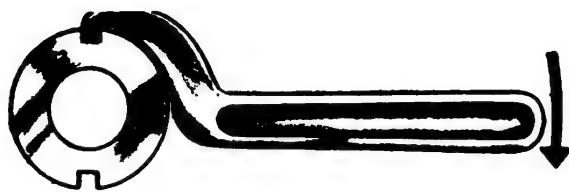
There are small, medium-sized, large and extra-large socket sets. There is always a size big enough for the job you're doing. Make sure you've got the right size. It will avoid the danger of overstraining the sockets and the handles.

The only things left to be said about socket wrenches are the commonplace things that cause so much trouble when you forget about them. Never use a bar on a socket wrench to increase the leverage. Remove the dirt and grease from socket sets and lubricate with a light coat of oil.

### SPANNER WRENCHES

The British call almost every wrench a "spanner." However, spanner wrenches, as they are known in the United States, are special wrenches for special jobs.

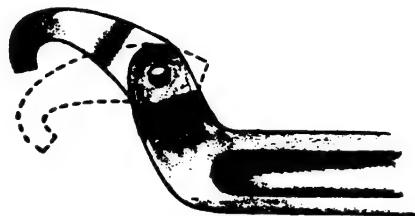
There are a number of types. The "hook spanner" is for a round nut which has a series of notches cut in the outer edge. See figure 22.



**HOOK SPANNER WRENCH**

Figure 22.

The hook or lug is placed in one of the notches with the handle pointing toward the direction in which the nut is to be turned. Some hook spanner wrenches are adjustable and will fit nuts of various diameters.



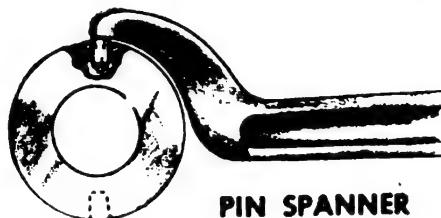
**ADJUSTABLE HOOK SPANNER WRENCH**

Figure 23.

U-shaped hook spanners have two lugs on the face of the wrench to fit notches cut in the face of the nut or screw plug.

End spanners resemble a socket wrench but have a series of lugs on the end that fit into corresponding notches in the nut or plug.

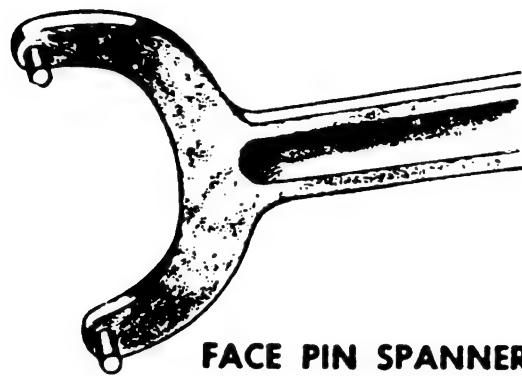
Pin spanners have a pin in place of a lug and the pin fits into a round hole in the edge of the nut.



**PIN SPANNER**

Figure 24.

Face pin spanners are similar to the U-shaped hook spanners except that they have pins instead of lugs.



**FACE PIN SPANNER**

**Figure 25.**

### **WHICH WRENCH TO USE**

Now that you know all the ordinary wrenches, you may wonder which is the best type of wrench to use for the particular job you're doing. Shall it be an open-end wrench, an adjustable wrench, a box wrench or a combination box and open-end wrench?

This is something best learned by actual experience, but there are a few simple rules which will be helpful. The type of job to be done, the location and number of nuts or cap-screws—these are the things to consider when selecting the wrench. Usually, if there are a number of nuts to be taken off or put on, you should use the socket-wrench set.

If there is plenty of room to operate a speed handle, transfer the socket to a speed handle and use this combination to spin off the nuts. In replacing and tightening the nuts, use the wrenches in the reverse order.

You're going to get a lot of actual experience, and after using each type of wrench a few times, you will find that it is not at all difficult to pick the right size wrench and to select the type best suited for the job.

## **REMEMBER TO—**

Use a wrench that fits the nut exactly.

Keep the wrenches clean and free from oil.

Otherwise they may slip, resulting in possible serious damage to parts.

Be careful about increasing the leverage on a wrench by putting a tube or extension on the handles, especially when tightening a nut. Increased leverage makes it easy to exert an undue strain on the bolt, resulting in either stripped threads or a broken bolt.

Provide some sort of a kit or case for all wrenches. Return them to their case at the completion of each job. This saves time and trouble and facilitates selection of tools for the next job. Most important, it eliminates the possibility of leaving them on the power plant where they may cause serious damage when the engine is started.

Determine which way a nut should be turned before attempting to loosen it. (Counter-clockwise, when looking toward the end of the bolt.) This may seem very elementary, but even experienced mechanics have been observed straining at a nut in the tightening direction when they wanted to loosen it.

## **PUNCHES**

In figure 26, you see several types of solid punches. These simple tools may be used for a variety of jobs, but you must select the correct punch for the job. "Starting punches," sometimes called drifts, are made with a long, gentle taper which extends from the tip to the body of the punch. They are made that way to stand heavy shock blows. This type punch is used to knock out rivets after the heads have been cut off. It

also is used to start driving out straight or tapered pins because it can withstand the heavy hammer blows required to break loose the pin and start it moving.

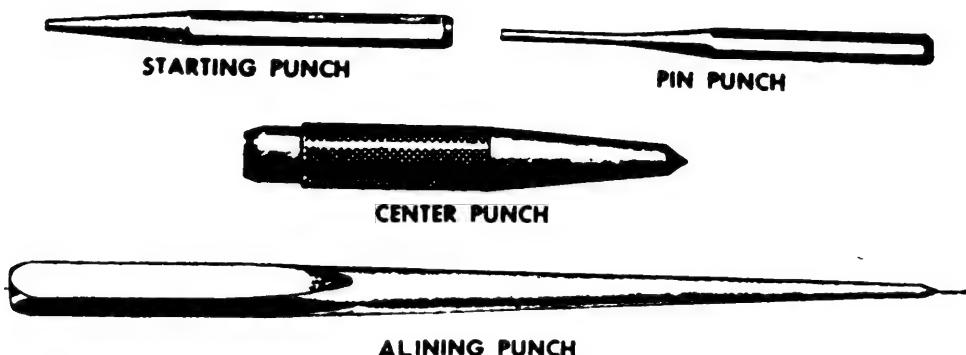


Figure 26.—Punches.

After the pin has been driven partially out of the hole, the starting punch can no longer be used. The increasing taper on the punch becomes too large for the hole. The next punch to use is a "pin punch." This is made with a straight shank—no taper—that fits into the hole. Always use the largest size of drift and pin punches that will fit the hole. Never use a pin punch to start a pin because it has a slim shank and a hard blow may cause it to bend or break. Starting punches and pin punches usually come in sets of various sizes with 3 to 5 punches in a set.

Every tool kit should contain an "alining" or "lining-up" punch which is from 12 to 16 inches long. This punch has a long taper and is useful in moving or shifting adjacent parts so that corresponding holes will "line-up." The punch is especially handy when you are making engine installations.

Another punch valuable in aviation work is the center punch. The center punch always is used to mark the location of a hole that is to be drilled. It

is used as a heavy duty punch and has a 90° point angle. When the drill is placed in the center punch mark, it will drill the hole at THAT PARTICULAR POINT. If you try to drill a hole without first locating it with a center punch mark, the drill usually will move all around the piece. This is called "wandering," and when a drill starts to wander, you don't have any control of the exact location of the hole.

Frequently, the cautious technician will use a center punch to make some corresponding punch marks on two or more parts in an assembly before he starts taking it apart. This will enable him to reassemble the parts in their original positions.

The point on a center punch is accurately ground to a true taper point which is central with the shank. Do not ever use the center punch to remove a bolt by force. The sharpened point will act as a wedge and will actually tighten the bolt in the hole. To remove a bolt by force, start with a drift that has a point diameter nearly equal to that of the bolt. When you remove a bolt, strike the exposed end of the bolt directly with the soft face of a hammer. You may then pull the bolt out from the opposite end. However, if it cannot be pulled, it may be driven out with the drift or pin punch.

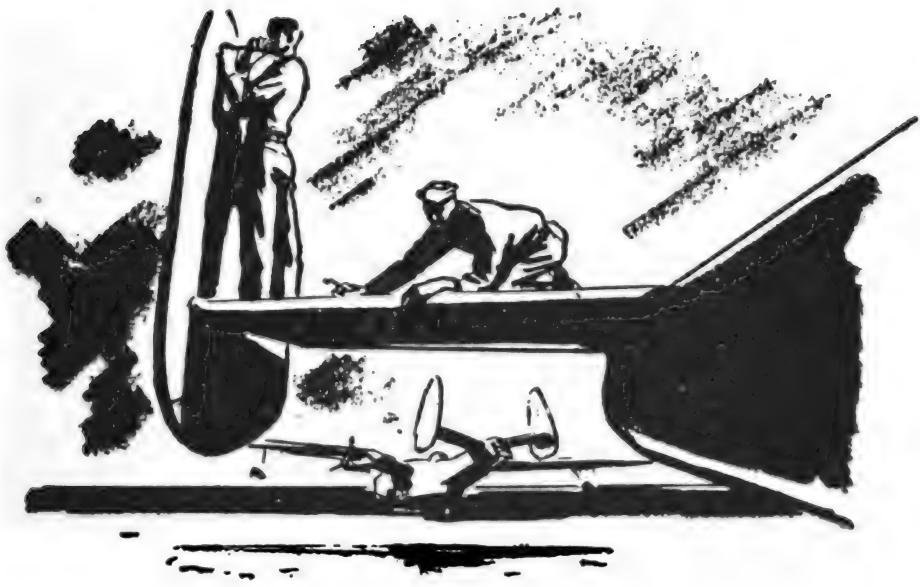
It requires considerable experience to grind a center punch point by hand with any degree of accuracy. So take care of the center punch. Don't use it on metal so hard that it may dull the point.

There are many types of punches which really come under the classification of special engine tools. Of these, one of the most popular types is the soft-faced drift. This is a brass or fiber tool designed for such purposes as removing shafts or wrist pins. It is heavy enough to resist damage to itself, and is soft enough not to injure engine parts.

The hollow-shank gasket punch is a handy and fast tool for cutting stud holes in gaskets. These punches—see figure 27—can be used in the field as well as the shop. They come in many sizes which will accommodate nearly all standard airplane bolts and studs. The cutting end is tapered to a sharp cutting edge to produce clean, uniform holes. First, lay the material to be punched flat on hard wood, lead, or something similar so the cutting edge will not become broken or damaged. Then with a hammer, drive the punch through the gasket where holes are needed.



Figure 27.—Hollow-shank gasket punch.



## CHAPTER 3

### SHAPING AND CUTTING TOOLS

#### CHISELS

Cold chisels are the tools to use for cutting or chipping metal. They are made of good grade tool steel with a hardened cutting edge and a beveled head at the opposite end. They will cut any metal which is softer than they are, or any metal that can be cut with a file. The width of the cutting edge of a cold chisel denotes its size. Chisels are used with a hammer or—if much metal is to be removed—with a pneumatic gun.

Usually the bar stock from which the chisel is forged is octagonal (eight-sided) but may be hexagonal (six-sided), round, square, or rectangular. They are classified according to the shape of their points. The commonest shapes are flat, cape, round nose, and diamond point as shown in figure 28.

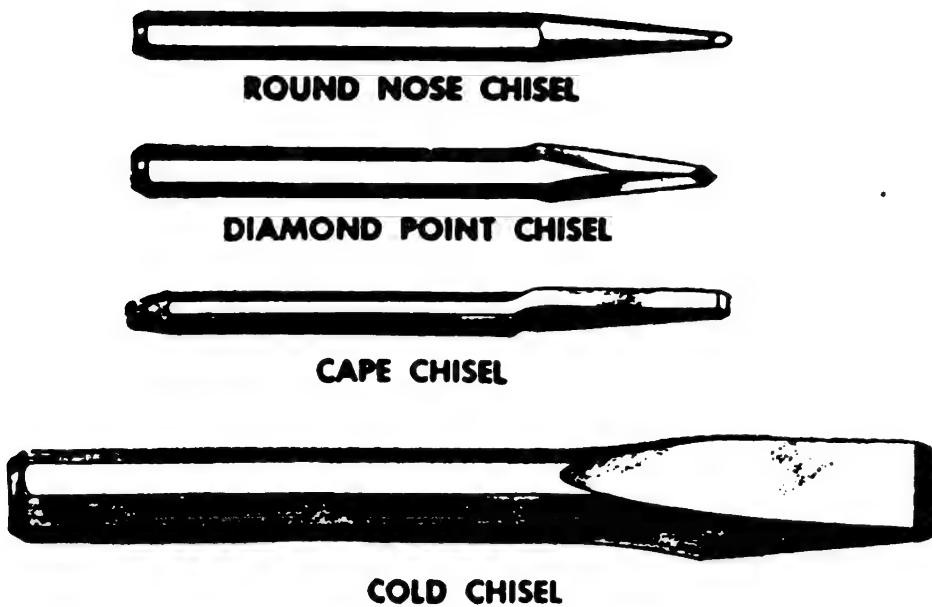


Figure 28.—Cold chisels.

Good results happen when you do things right. One of the right things to do, when chiseling, is to use the type of cold chisel that has been designed for the particular work you want to do. For instance, if you're going to chip or cut thin sheet metal, remove stock from flat surfaces, cut rivets, or split nuts, use a FLAT COLD CHISEL.

If the work involves cutting such things as keyways, narrow grooves, square corners, or slots, use a CAPE CHISEL. This is narrow in width and can also be used to chip flat surfaces that are too wide for a flat chisel.

Round or semicircular grooves should be cut with a ROUND-NOSE CHISEL. This tool is also the one to use for chipping inside corners which have a fillet (curved junction) and for drawing back drills which have "run out."

The DIAMOND-POINT CHISEL is made square at the point, then ground on an angle across diagonal corners which makes the cutting face diamond-shaped. Use it for cutting V grooves and square corners.

## HOW TO USE COLD CHISELS

As a rule, the cold chisel is used for cutting wire or small round stock or for cutting sheet metal or plates. Look at figure 29. It is an illustration of the correct way to hold the hammer and chisel and the best position for the work.

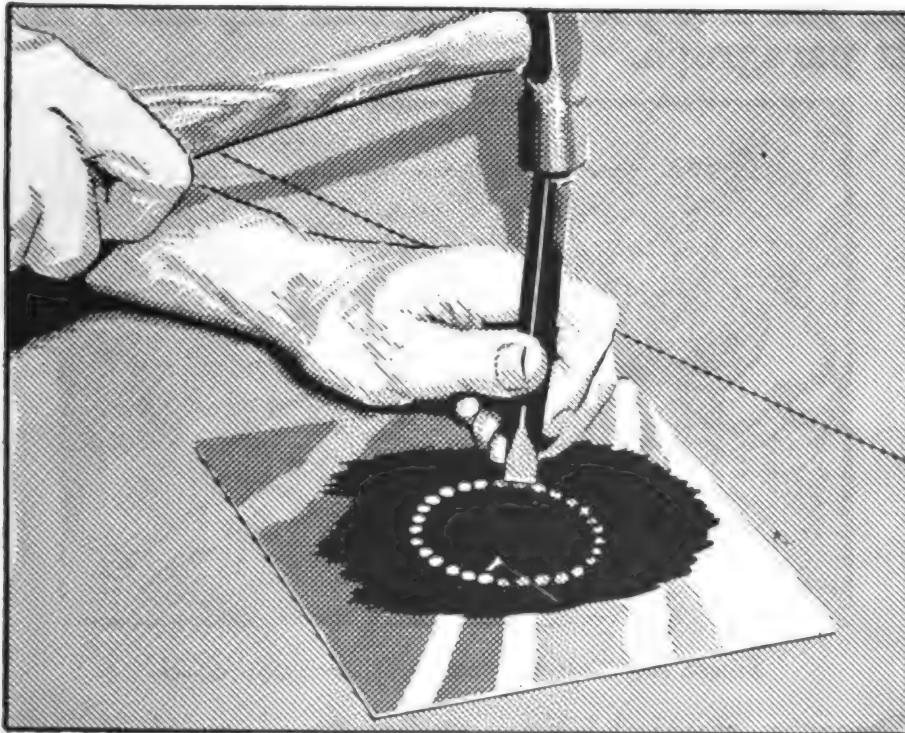


Figure 29.—Good chiseling technique.

Ordinarily, you should hold a chisel in your left hand with finger muscles relaxed. Your grip on the chisel should be steady but rather loose. It is best to watch the edge, not the head, of the chisel while working. Strike sharp, quick blows, taking care that the hammer does not slip off the end of the chisel and injure your hand.

Hold the cutting edge of the chisel at the point where the cut is desired. After each blow of the hammer, set the chisel to the correct position for the next cut. The depth of the cut depends on the angle at which the chisel is held in relation to the

work. The sharper this angle, the deeper the cut will be. Don't try to take too deep a cut. For rough cuts,  $\frac{1}{16}$  of an inch is enough, but half that much or less is plenty for finishing cuts.

Avoid cutting plate or thick sheet metal with a cold chisel whenever possible, as the metal will invariably stretch. However, when this must be done, the best procedure is that explained in the next paragraph.

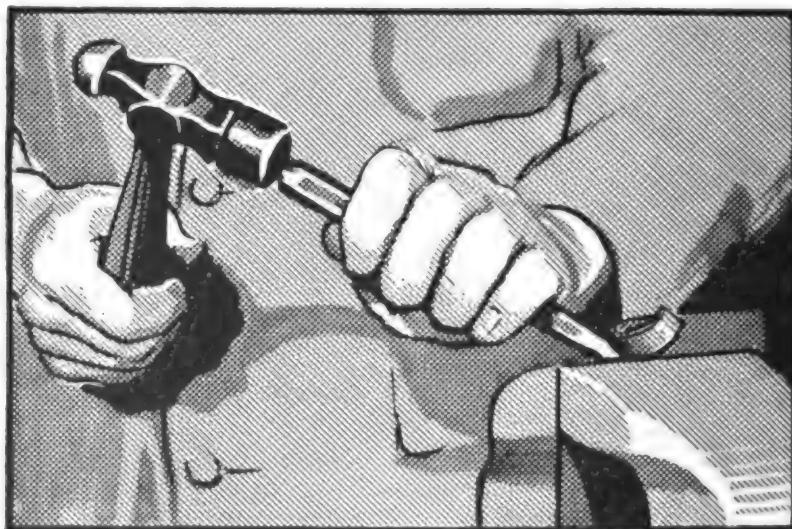


Figure 30.—Cutting sheet metal with cold chisel.

Draw a straight line on the work with a scribe where the cut is to be made. Grip the work firmly in a vise with the scribed line even with or just about at the top of the vise jaws, as shown in figure 30. The waste metal should extend above the jaws as shown in the illustration. Start at the edge of the work and cut along the scribed line with a sharp chisel. Use the vise jaws as a base for securing a shearing action. Hold the chisel firmly against the work and strike it vigorously. Be sure to keep the cutting edge of the chisel flat against the vise jaws, as shown in figure 30.

When chipping steel, lubricate the chisel point with light machine oil. This will make the chisel easier to drive and cause it to cut faster than it

would if dry. When chipping cast iron, chip from the edges of the work toward the center to avoid breaking off corners.

### IMPORTANT THINGS TO REMEMBER

Like all cutting tools, chisels must be sharp to give satisfactory service. You can sharpen a chisel by dressing it on an emery wheel, or on an ordinary coarse grinding wheel. The cutting angle should be about  $60^{\circ}$  and the edge slightly rounded.

When sharpening a chisel, try to maintain the original angle of the cutting edge by grinding only a small amount at a time from each side. Hold the chisel against the wheel with very little pressure to avoid overheating, and dip the cutting end of the chisel in water often enough to keep it cool. Otherwise the heat generated will change the temper of the steel. If this happens, the cutting edge of the chisel will be soft and it will be useless until it is rehardened and tempered. If the cutting

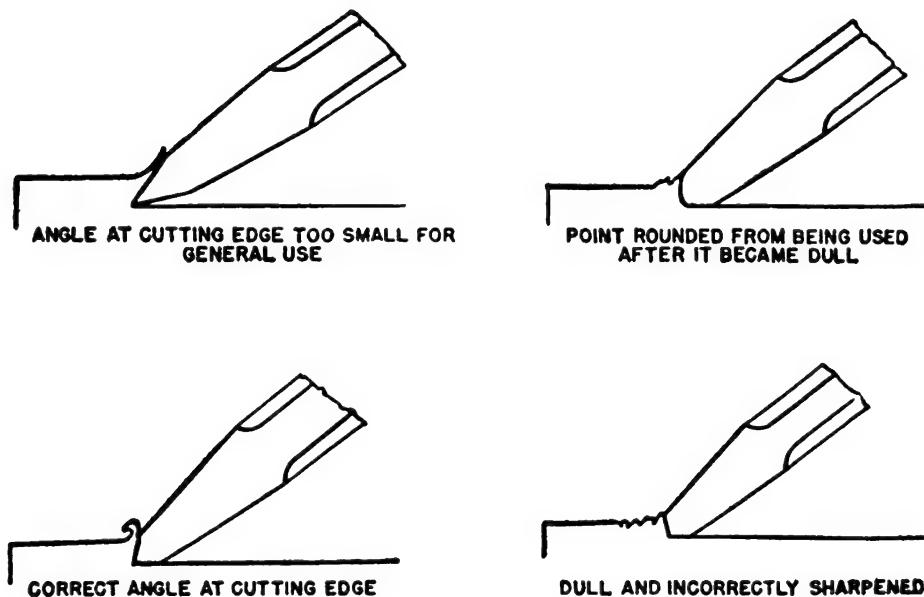


Figure 31.—Results of correct and incorrect sharpening.

angle is ground too small, the chisel will not be safe to use. Or, if this angle is much over  $60^{\circ}$ , the tool will not cut properly. The results of correct and incorrect sharpening are shown in figure 31.

Blows of the hammer will eventually cause the blunt end of the chisel to spread out until it resembles a mushroom. When this happens, grind the end back to its original shape. It is dangerous to use a chisel with a mushroom head because pieces may fly off and cause injury.

When using a chisel for chipping, always wear goggles to protect your eyes. If there are other men close by, see that they wear goggles or are protected from flying chips—put up a screen or shield to keep the chips from hitting anyone. These few precautions can save many a man from losing the sight of an eye. Remember that the time to take these precautions is before you start the job. After somebody is injured, it's too late.

Use a hammer that is heavy enough for the size of the chisel. The larger the chisel, the heavier the hammer should be. Keep the hammer and the blunt end of the chisel clean and free of grease or oil to prevent the hammer from slipping and bruising your hand.

If the work is held in a vise, the jaws should have guards made of soft material, such as copper or brass, to protect the finish on the work. Always chip toward the solid jaw of the vise. Never chip toward the movable jaw. Where possible, avoid chipping parallel with the jaws.

## HACKSAWS

Hacksaws are used to saw metals. There are two parts to a hacksaw—the frame and the blade. Common hand hacksaws have either adjustable or solid frames. See figure 32 for examples of both.

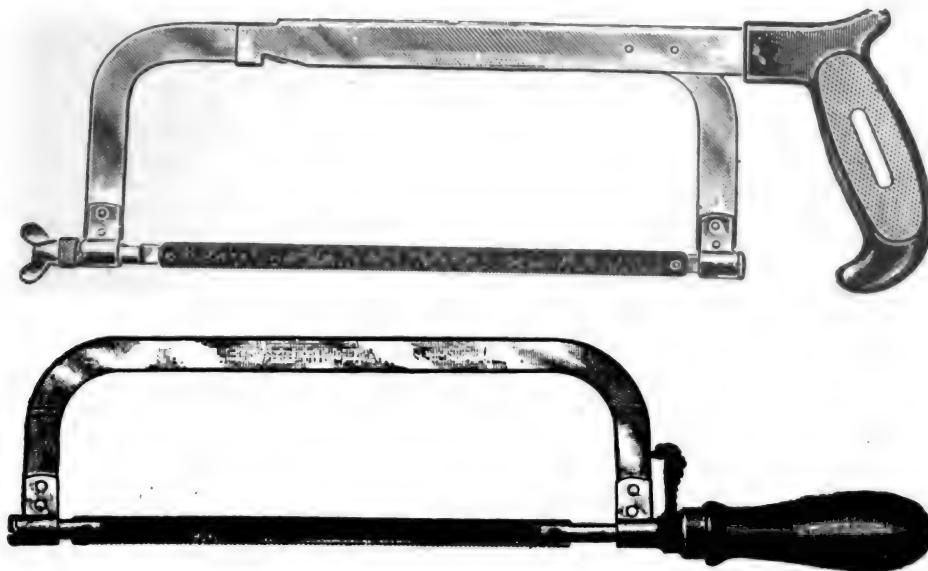


Figure 32.—Hacksaws.

However, most hacksaws are now made with an adjustable frame. Hacksaw blades of various types are inserted in these adjustable frames for different kinds of work. Adjustable frames can be changed to hold blades from 8 to 16 inches long. Solid frames, although more rigid, will take only the length blade for which they are made. This length is the distance between the two pins which hold the blade in place.

The better frames are made with a pistol-grip handle. Recently, several manufacturers have put out frames with the handle in an inverted position. The idea is that the force applied on the forward stroke of the saw is delivered in direct line with the blade.

Hacksaw blades are made of high-grade tool steel, hardened and tempered. There are two types, the all-hard and the flexible. All-hard blades are hardened throughout whereas only the teeth of the flexible blades are hardened. Hacksaw blades are about  $\frac{1}{2}$  inch wide, have from 14 to 32 teeth per inch, and are from 8 to 16 inches long. The blades have a hole at each end which hooks to a pin in the frame. All hacksaw frames which hold the blades either parallel or at right angles to them are provided with a wing nut or screw to permit tightening or removing the blade.

The SET in a saw refers to how much the teeth

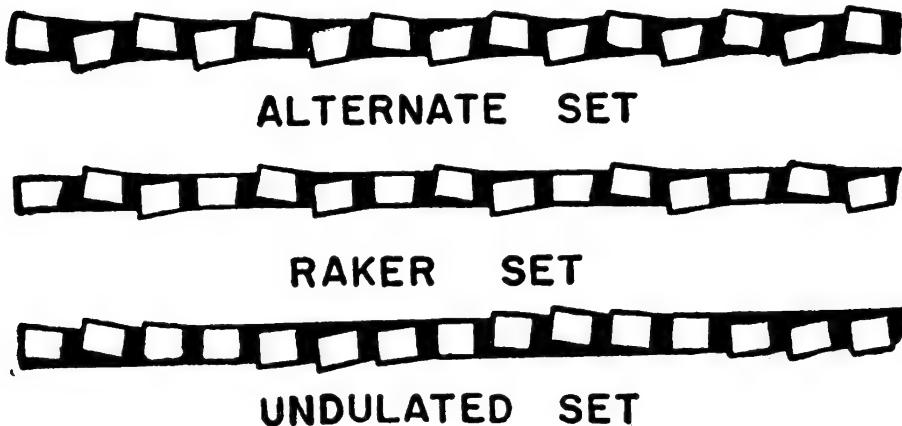


Figure 33.—"Set" of hacksaw blade teeth.

are pushed out in opposite directions from the sides of the blade. The teeth of all hacksaw blades are set to provide clearance for the blade. The four different kinds of set are ALTERNATE set, DOUBLE ALTERNATE set, RAKER set, and WAVE set. Three of these are shown in figure 33.

The teeth in the alternate set are staggered, one to the left and one to the right throughout the length of the blade. On the double alternate set blade, two adjoining teeth are staggered to the right, two to the left, and so on. On the raker set blade, every third tooth remains straight and the

other two are set alternately. On the "wave" or undulated set blade, short sections of teeth are bent in opposite directions.

Selecting the best hacksaw blade for a specific job is a question of using either an all-hard or a

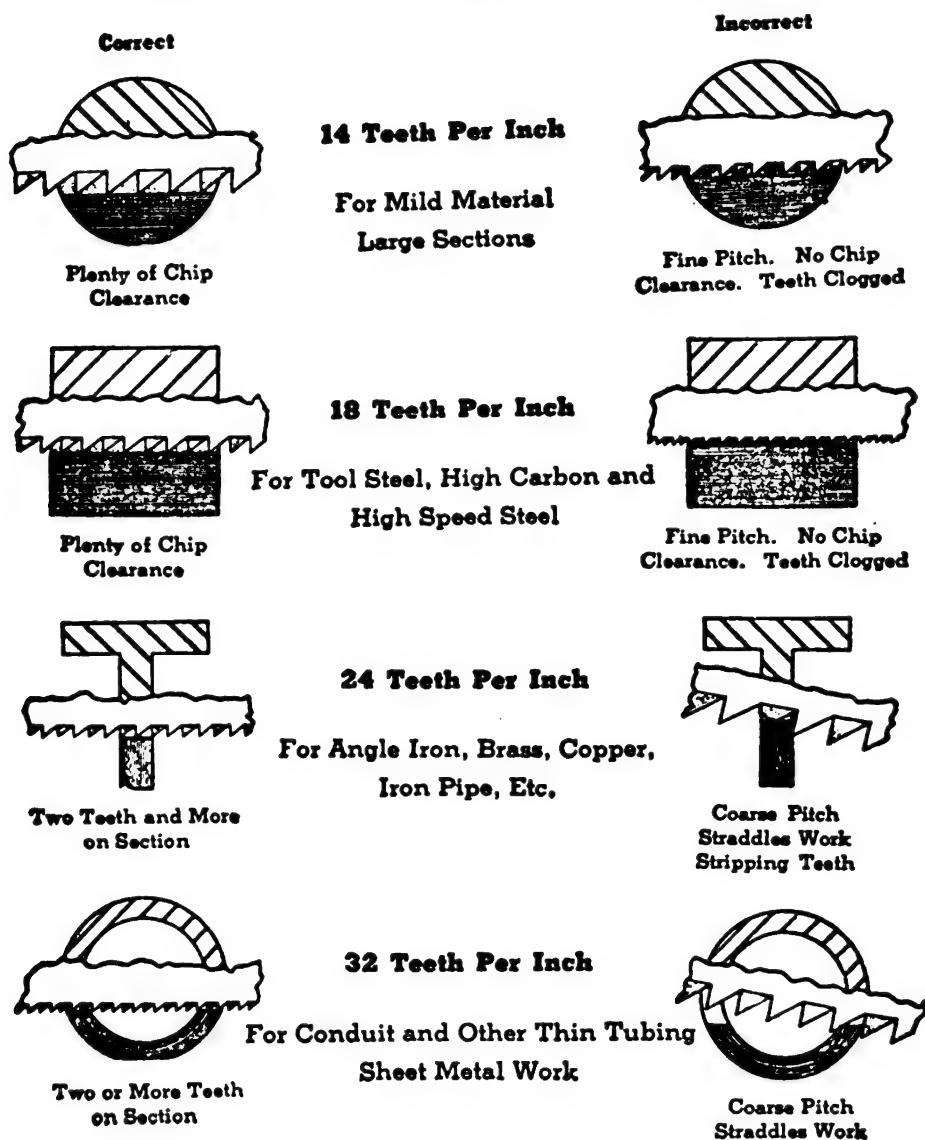


Figure 34.—Correct pitch of hacksaw blades.

flexible blade having a pitch best suited to the work. The pitch is the number of teeth per inch. The following practices seem to be the best ones for selecting the right hacksaw blade for the job. An all-hard blade is best for sawing brass, tool steel,

cast iron, rails, and other stock of heavy cross section. In general, a flexible blade is best for sawing hollow shapes and metals of light cross-section, such as channel iron, tubing, tin, copper, aluminum, or babbitt.

Figure 34 is an illustration of the principles involved in selecting blades with the most suitable pitch for most jobs.

Use a blade with 14 teeth per inch on machine steel, cold rolled steel, or structural steel. This coarse pitch makes the saw free and fast cutting. Use a blade with 18 teeth per inch on solid stock, aluminum, babbitt, tool steel, high-speed steel, cast iron, and so on. This pitch is also recommended for general use.

Use a blade with 24 teeth per inch on tubing, tin, brass, copper, channel iron, and sheet metal over 18 gage. If a coarser pitch is used, the thin stock will tend to strip the teeth out of the blade and make it difficult to push the saw. If you have occasion to saw thin sheet metal, clamp it in a vise between two pieces of wood. Use a blade of the many tooth type (with 32 teeth per inch) on thin-walled tubing and conduit and on sheet metal thinner than 18 gage.

After selecting the correct blade, place it in the hacksaw frame, making sure it is stretched tightly in the frame. Place the blade on the pins with the teeth pointing TOWARD THE FRONT—away from the handle. Then tighten the adjustments so that the blade is rigid in the frame.

Mark the stock at the point to be cut with a scribe, soapstone, or pencil. If you are making a cut to a marked line, it's a good idea to nick the work with a file and start the saw in the nick. Use sufficient pressure in starting the cut so that the saw immediately begins to bite into the metal. Be sure the work is gripped tightly in a vise, with

the line to be cut as close to the vise jaws as possible. In cutting angle iron or any odd-shaped work, expose as much surface as possible so that a cut can be started gradually with the maximum number of teeth engaged throughout the cut.

Start cutting on the widest surface of the work. Figure 35 is an illustration of the right and wrong ways to do it.

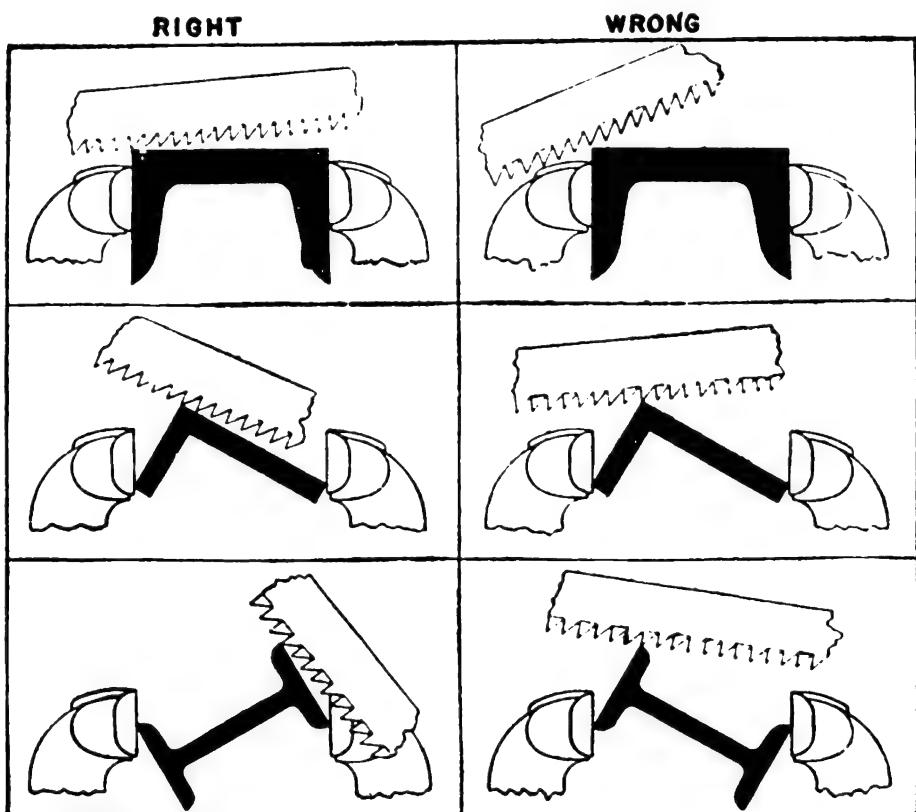


Figure 35.—Starting hacksaw cuts.

The hacksaw blade should be held vertically and moved forward with a light, steady stroke. At the end of the stroke, relieve the pressure and draw the blade STRAIGHT BACK.

After the first few strokes, make each one as long as possible without striking the saw frame against the work. Do not bear down on the saw on the return stroke. Keep the saw in the same place

throughout the cut. If you don't, the blade may be cramped and broken.

To make a cut deeper than the frame, it is sometimes possible to turn the blade sideways as shown in figure 36.

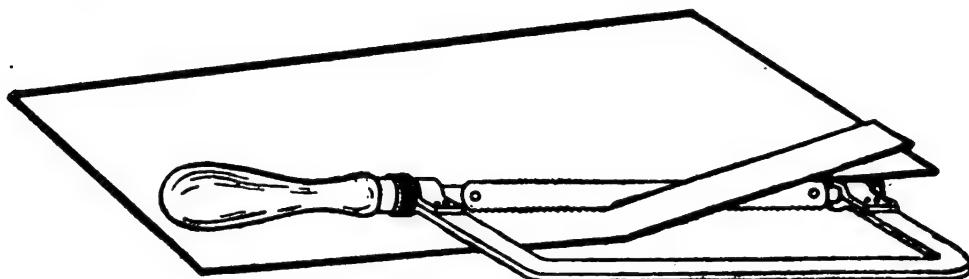


Figure 36.—Cutting deep.

The most effective cutting speed is about one stroke per second. When the work is cut nearly through, use slightly less pressure on the cutting stroke to prevent the teeth from catching. Special care is needed toward the end of a cut through thin material. When cutting very thin stock, clamp the work between two pieces of wood or soft metal and saw through all three pieces. This will prevent shattering and possible damage to the work.

For efficient cutting in metals of average hardness, work the saw at the rate of 40 to 50 strokes per minute. If you saw too fast, there may be sufficient heat generated by the cutting action of the teeth to draw the temper and ruin the blade. In cutting harder metals, the number of strokes per minute should be reduced. To avoid ruining all the teeth on a blade, test the metal with the very front or rear teeth or with the tip of a file to see if it can be cut.

It is sometimes possible to remove broken studs by sawing a screw-driver slot in the broken end of the stud shank and backing it out with a screw driver. Use a hacksaw fitted with two blades instead of one for work of this type or where it is

desirable to remove considerable metal in a cut. This will make a cut wide enough to fit the screw-driver tip.

The chief danger in using hacksaws is injury to your hand if the blade breaks. The blade will break if too much pressure is applied when the saw is twisted or when the cutting speed is too fast. If the work is not tight in the vise, it will sometimes slip, twisting the blade enough to break it.

If you watched an experienced mechanic taking care of a hacksaw, you'd probably see him doing such things as properly protecting the blade when not using it, hanging up the hacksaw in the shop, putting it in the tool kit in a place where tools and other metal objects do not rub against the blade teeth, and wiping the blade occasionally with an oily cloth to keep it from rusting.

### THE CIRCULAR-HOLE SAW

There are many methods of cutting round holes in airplane skin and bulkheads. The circular-hole saw does the neatest job. This cup-shaped saw can be clamped in the chuck of the hand drill, electric drill, breast drill, or flexible adapters.

During the installation of new equipment in the airplane, it is often necessary to run lines or controls through the fuselage or hull. A job of this nature often calls for making holes from one station to another. This is where the use of the hole cutter comes in handy.

The hole saw comes in many diameters of whole inches or inches and fractions of inches. It has a centering adapter shaft to which the saw is clamped by a locking nut, which also clamps the pilot drill in place. The pilot drill is allowed to extend about  $\frac{1}{8}$  inch past the cutting teeth of the saw. Running the pilot through material in which

the hole is to be cut tends to hold the saw steady. When completed, it leaves a perfectly round, clean hole.

If overheated, these saws become jammed and clogged with metal which, under pressure, often cracks the cup-shaped body. To prevent this, have a little soap or kerosene handy to apply to the cutting teeth.

The FLY CUTTER is also used for cutting circular holes in metal sheets. The advantage of this cutter is that it can be adjusted to cut any size hole within its capacity.

The BENCH VISE is used for clamping work between its jaws. The handle turns the clamp screw which moves the outside jaw, clamping the work. On many vises, the immovable jaw is fixed to a swivel base that can be rotated on its axis to secure a better position for the work.

The vise jaws are hardened and notched to grip the work rigidly. Any work that must not be marred can be protected by using soft removable jaws. The removable jaws are made of soft materials such as brass, copper, or leather.

## FILES

Your kit will not be complete without an assortment of files. Files are hardened steel tools used for cutting, removing, smoothing, or polishing metal. The cutting edges or teeth on the surface are made by diagonal rows of chisel cuts. The rasp is similar to the file except that it has coarse teeth raised by a triangular punch.

There are many types of files. They may be either single or double cut and are further classified according to different grades of coarseness or fineness, depending on the size and spacing of the teeth.

The portion of the file on which the teeth are cut is called the "face." The tapered end that fits into the handle is called the "tang." The part of the file where the tang begins is the "heel." The length of a file is the distance from the point or tip to the heel and does not include the tang. In other words, it is the total length of the file minus the length of the tang. All of this is pictured in figure 37.

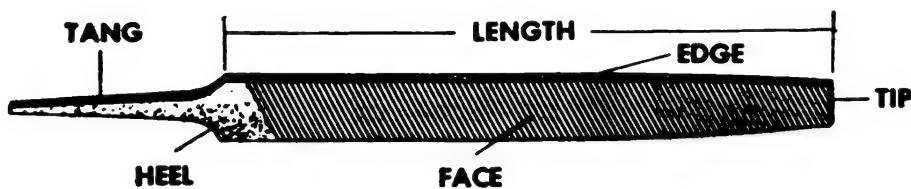


Figure 37.—The file.

The teeth of the file do the cutting. These teeth are set at an angle across the face of the file. A file with a single row of parallel teeth is called a single-cut file. The teeth are cut at an angle of 65 to 85 degrees to the center line, depending on the intended use of the file.

Files which have one row of teeth crossing another row in a criss-cross pattern are called double-cut files. The angle of the first set usually is 40 to 50 degrees and that of the crossing teeth 70 to 80 degrees. Criss-crossing produces a surface which has a very large number of little teeth all slanting toward the tip of the file, each little tooth like the end of a diamond-point chisel. See figure 38.

Files are graded according to the spacing of their teeth. A coarse file has a small number of large teeth and a smooth file has a large number of fine teeth. The coarser the teeth, the more metal will be removed on each stroke of the file. The terms used to indicate the coarseness or fineness of a file are rough, coarse, bastard, second-cut, smooth, and dead-smooth. And the file may be either single-cut or double-cut.

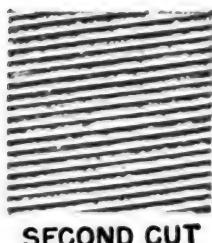
### DOUBLE CUT FILE



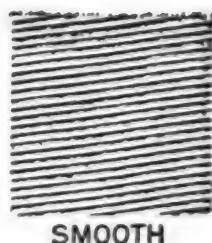
### SINGLE CUT



BASTARD CUT

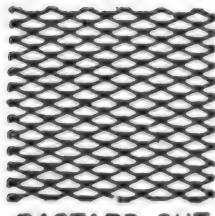


SECOND CUT

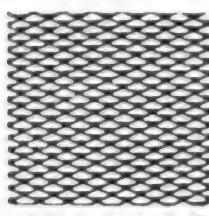


SMOOTH

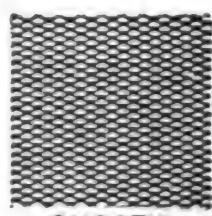
### DOUBLE CUT



BASTARD CUT

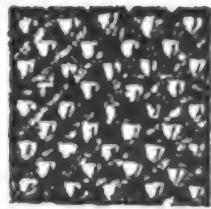


SECOND CUT

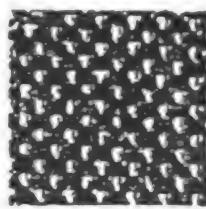


SMOOTH

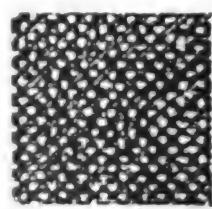
### RASP CUT



BASTARD  
WOOD RASP



SECOND CUT  
CABINET



SMOOTH  
CABINET

Figure 38.—Files and rasps.

Files are further classified according to their shapes. These are on display in cross section in figure 39. To keep the subject of files from becoming too complicated and to avoid discussing a lot of files you will never see or use, only the really common files are presented.

The mill file is single-cut, tapering in thickness and width for one-third of its length. Useful for fine work, it can be had with either square or round

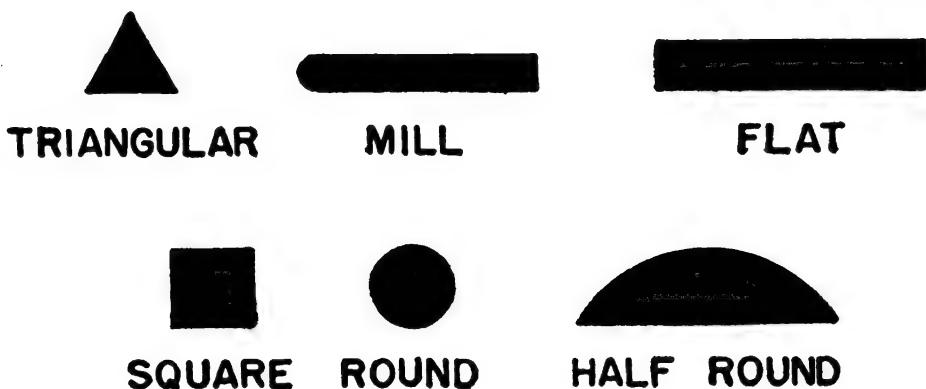


Figure 39.—Shapes of files.

edges or with one safe edge. The safe edge is smooth and has no cutting teeth. The 12-inch second-cut mill file is used for removing a small amount of metal and making the filed surface smooth. The 6-inch smooth mill file is used for all small work where surfaces are flat or convex.



Figure 40.—Mill file.

A double-cut file tapering in thickness and width is the flat file, used principally when a fast-cutting tool is desired. You can use the 12-inch flat bastard file, if you want to, for general rough filing.



Figure 41.—Flat file.

The round file is tapered and usually single-cut, although it is sometimes double-cut in the larger sizes. The 12-inch round bastard file is used for

enlarging holes, also for filing surfaces having small concave radii.

The 6-inch round file, frequently called a rat-tail file, is used for purposes similar to the 12-inch round file but on smaller work. There are also parallel or untapered round files.

The principal use of all round files is to enlarge circular openings or concave surfaces.



Figure 42.—The round bastard file.

The half-round file is a double-cut file tapering in thickness and width with one flat and one oval side. This type of file is used to remove stock rapidly and to file concave surfaces.

The rounded face of the 12-inch half-round bastard file is used to file a surface having a large concave radius. The flat face can be used for general rough filing.

The 6-inch half-round second-cut file is used for similar purposes but on smaller work where you do not have to remove too much metal.

The hand file is single-cut and similar in shape to a flat file, with parallel sides and a slight taper in thickness. It has square edges, one of which is a safe edge.

The 6-inch three-square or triangular file is useful for filing small notches, square or cornered holes, and for straightening up burred or damaged threads.



Figure 43.—The 6-inch three-square file.

Files are available in almost any shape and size. A small flat file of special composition, known as an

ignition file, is used extensively in aviation work for filing tungsten breaker-contact points.

### CHOOSE THE RIGHT ONE

A little thought goes a long way when it comes to the selection of files. For instance, a large, coarse, double-cut file is the one you'll want for heavy, rough cutting. When finishing cuts, use a second-cut or a smooth single-cut file.

Start with a bastard-cut file and finish with a second-cut when filing cast iron. If you're filing soft steel, start with a second-cut and finish with a smooth-cut. If it's hard steel, start with a smooth-cut file and finish with a dead-smooth one.

With brass or bronze, file with a bastard-cut and finish with a second- or smooth-cut file. Use a bastard file, or even better, a float-cut or vixen-cut as shown in figure 44 when filing aluminum, lead, or babbitt metal.

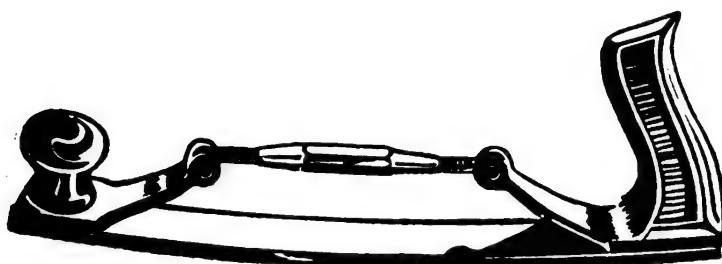


Figure 44.—Float-cut file.

Use the short 1-, 2-, or 3-inch file for small work; 6-, 8-, and 10-inch files for medium-size work; and a file as large as you can use conveniently for large work.

Don't use a file that is not equipped with a tight-fitting handle. It's dangerous—the end of the tang is sharp. If you use a file without a handle and the file happens to bump into something, the tang will be driven into your hand.

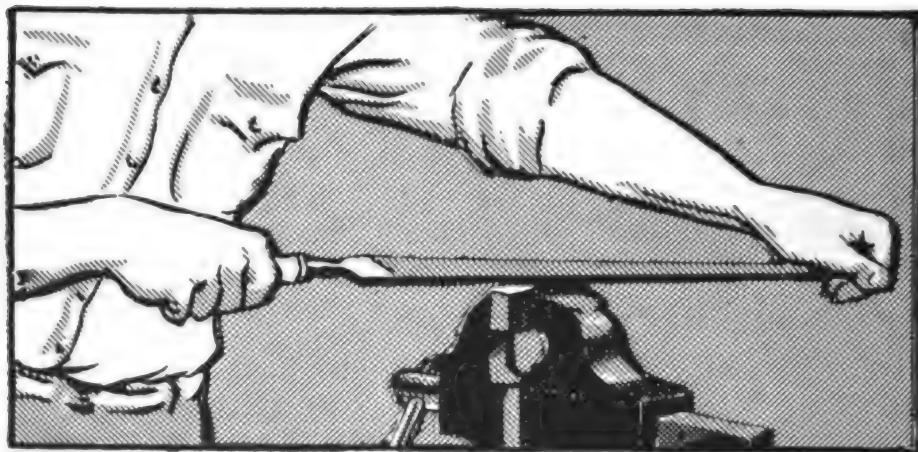


Figure 45.—Correct way to hold a file.

To put a handle on a file, first make sure the handle is the right size and that the hole is large enough for the tang. Insert the tang of the file into the hole in the handle, then tap the back end of the handle on the bench or a flat surface on the vise. Make sure the handle is on straight.

To remove a file handle, hold the handle in your right hand and hold the file with your left hand and give the ferrule end of the handle a sharp rap against the edge of the bench or the side of a vise jaw. Now, work the tang out of the handle. The ferrule is the metal sleeve on the hole end of the handle which keeps the handle from splitting when the tang of the file is forced into the hole.

Whenever possible, the part to be filed should be clamped rigidly in a vise. To prevent rough vise jaws from damaging finished surfaces, use copper caps or other soft material.

The best way to hold a file is with the handle against the palm of your right hand, thumb on top, as shown in figure 45. Hold the end of the file in your left hand with your fingers curled under it. When filing, lean your body forward during part of the forward stroke and straighten up at the finish. Hold the file straight or the surface of

the work will not be flat. No more than 30 or 40 strokes per minute should be taken. Too much speed will ruin the file and the work.

The teeth of a file are made to cut in **ONE DIRECTION ONLY**—when the file is being pushed forward. All pressure of the file against the work should be relieved on the back stroke. Unless the file is lifted from the work on the return stroke, it will become dull quickly. The preferred method of using a file is to raise it off the work before drawing it back.

There are exceptions to this rule. When you are filing very soft metals, such as lead or aluminum, a slight pressure on the return stroke helps keep the cuts in the file clean of the removed metal.

When you start to use files, you'll want to know just how much pressure to use. Don't "bear down" on a file. **TOO MUCH PRESSURE IS ALMOST AS BAD AS TOO LITTLE PRESSURE.** The point to remember is to **USE ONLY SUFFICIENT PRESSURE TO KEEP THE FILE CUTTING.** Different metals and different files call for a difference in the amount of pressure you should apply to the file.

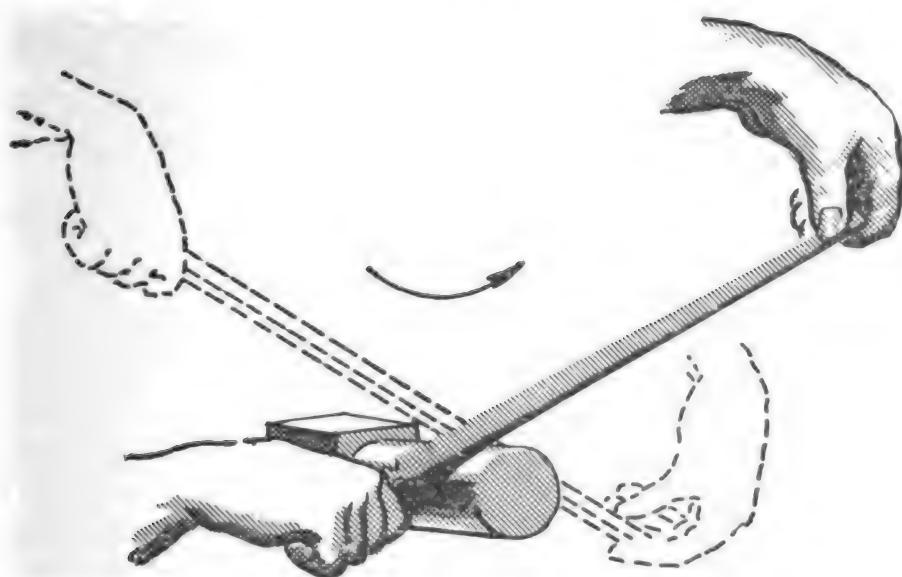


Figure 46.—Filing round surfaces.

Round surfaces require a little different technique. You'll get the best results by using the rocking motion shown in figure 46. Hold the work firmly in a vise, with the surface to be filed projecting slightly above the vise jaws, and parallel to them. If the work is loose in the vise, the file will chatter. This damages its teeth and the work.

Work is sometimes "draw-filed" to produce a very smooth surface. In draw filing, move the file sidewise along the work as shown in figure 47. A

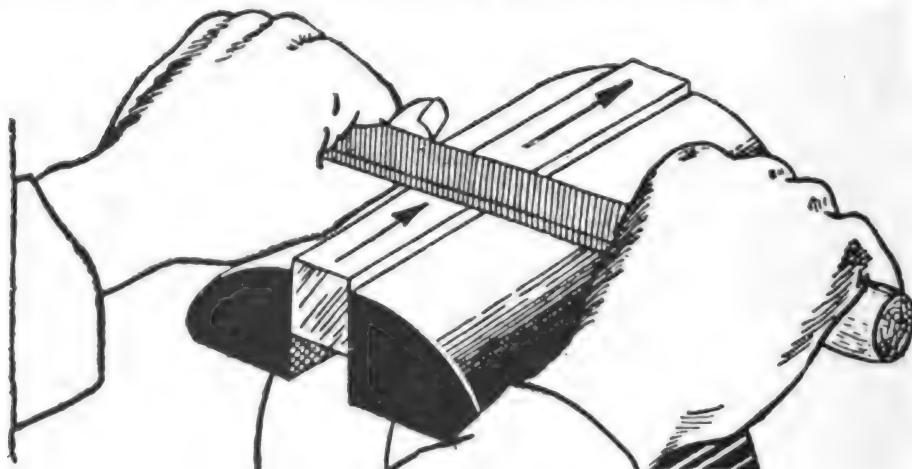


Figure 47.—Draw filing.

single-cut smooth file should be used. Put the pressure on the forward stroke and keep it light on the return stroke. For a still smoother surface, wrap a piece of fine emery cloth around the file and proceed as in draw filing.

#### PINNING

When filing soft metals, narrow surfaces, or in corners, small particles from the work are likely to clog the teeth of the file and scratch the material being filed. This is called "pinning." Pinning usually happens when you put too much pressure on the file, especially if it is a new one. To avoid this, be sure the file is broken in before taking heavy

cuts. Suggestion—rub chalk on a file before using it to help prevent pinning.

## BREAKING IN

A new file should be broken in by using it first on brass, bronze, or smooth cast iron. A new file should NOT be broken in on a narrow surface, such as the edge of a strip of sheet iron. The narrow edge is likely to break off the sharp points of the bank. This same new file should never be used to remove the scale on cast iron. Most of the damage to new files is caused by using too much pressure during the first few strokes.

## CLEANING

Never use a file after the teeth become choked or clogged with particles of metal. The experienced technician will bump the tip of the file or the end of the handle on the bench every now and then to jar loose the filings which stick in the teeth. This won't always get out all the chips, so the thing to do when the file gets "loaded" is to clean it with a FILE CARD. This is a steel wire brush. Check figure 48 for an illustration of a file card.

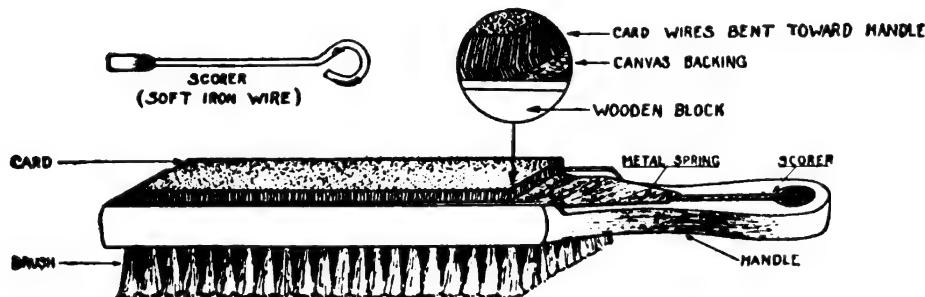


Figure 48.—File cleaner.

If there are any chips remaining after using the file card, dig them out with a pick. A pick is a small, pointed, wire instrument, often furnished with a file card. Use it to clean out individual cuts

in a file that is clogged too tightly with metal to permit cleaning with a file card. A file loaded with chips will roughen a surface which you want to file smooth, especially if the material you are filing is steel.

To clean a file, lay it flat on the bench and draw the file card and brush back and forth across it, parallel with the cuts. Finish by brushing the file lengthwise.

### HANDLING

Files must be kept sharp to do their best work. They should never be used on material harder than themselves or on a sandy or scaly casting. One stroke across such sand or scale will make any file useless. Metals which are soft and tough, such as copper and certain brass alloys, require the use of very sharp files.

To keep files sharp, protect their surfaces when not in use. A file is easily dulled by rough or improper handling. The best way to protect files in the shop is to hang them in a rack which has a series of slots. Files carried in a tool box should be wrapped in cloth, paper, or other material to protect them from other tools. Don't throw files around on a bench or into a drawer with other tools. And keep them away from moisture or water to prevent rusting. For best results and long file life, use the file card and brush often.

Never use a file for prying. The tang end is soft and bends easily. Also, the body of the file is hard and very brittle. Even a light bending force will snap it in two. A final and very important precaution—NEVER HAMMER ON A FILE. The file may shatter with chips flying in every direction.

### HAND SNIPS

Hand snips are mighty handy instruments.

The STRAIGHT HAND SNIPS, shown in figure 49, have blades that are straight and cutting edges that are sharpened to an  $85^{\circ}$  angle. Snips like this can be obtained in many different sizes ranging from the small 6-inch snip to the large 14-inch one. They are usually designed to cut sheet metal up to  $\frac{1}{16}$  of an inch in thickness. They will also work on slightly heavier gages of aluminum alloy.

Unlike hacksaws, straight snips won't remove a certain width of metal when a cut is made. There is more danger, though, of causing minute metal fractures along the edges of the metal during the shearing process. For this reason, it is better not

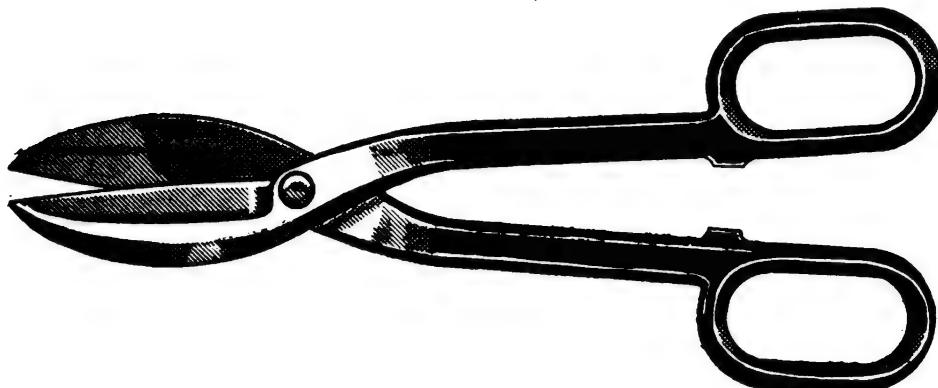


Figure 49.—Straight hand snips.

to cut exactly on the layout line in an attempt to avoid too much finish work.

Just cut as close to the layout line as is safe. There is no set rule for this measurement. You can proceed safely, however, on the assumption that the thinner and softer the metal is, the closer you can cut to the layout line. If metal is hard and thick, you can very easily fracture it in the cutting practice. Some fractures are so severe that they cannot be removed when the metal is dressed to size.

Leave about  $\frac{1}{32}$  of an inch for dressing. When cutting from the edge of a large sheet, you'll have better luck if you cut from the left-hand side. You

can get an idea of this process from figure 50. If the sheet is cut from the left a small section of

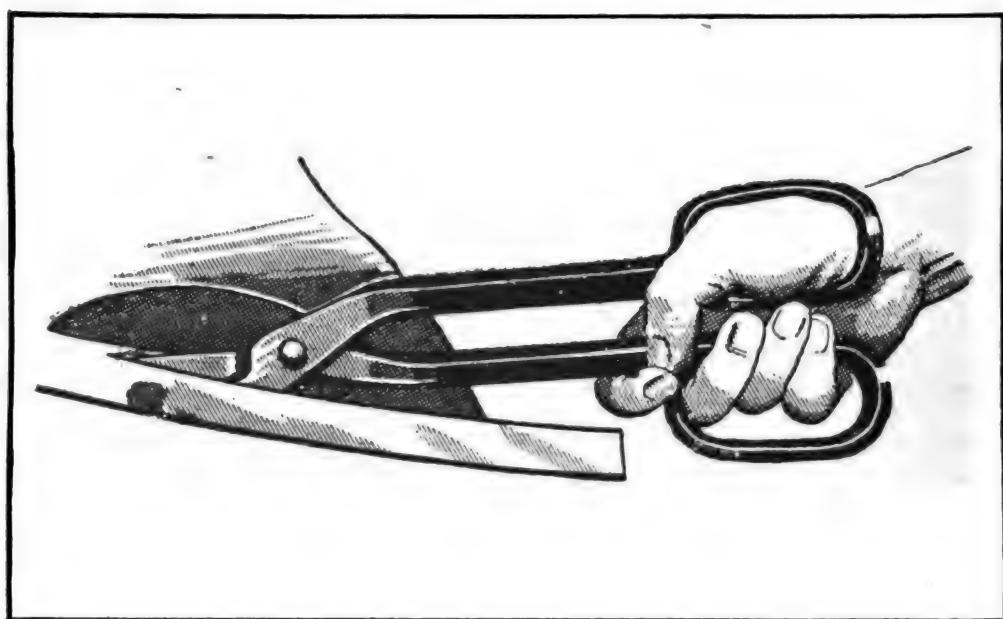


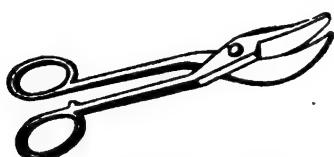
Figure 50.—Cutting from the left-hand side.

scrap material will curl upward while the larger pieces of material will remain flat. When the left-hand portion of the material curls upward, it provides clearance for the frame of the shears to advance along the cut. The cut should never be made the full length of the blade. If the points of the snips are allowed to come together, they will tear the metal as the cut is completed. Stop the cut approximately a quarter of an inch before the end of the blades have been reached and then take a new bite.

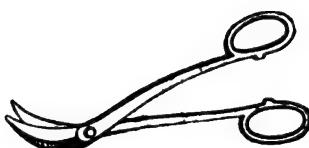
Suppose that you have to cut extremely heavy metal. This always presents an opportunity to spring the blades. Once the blades are sprung, hand snips are useless. USE THE REAR PORTION OF THE BLADES ONLY when cutting heavy metal. This not only avoids any possibility of springing the blades, it gives greater leverage. Hand snips will

withstand a lot of hard use but there is a limit to their endurance. Never use them to cut hardened steel wire or other similar objects. Such use will dent or nick the cutting edges of the blades.

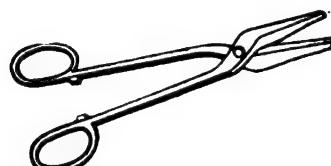
It's a tough job to cut circles or arcs of small radii with straight snips. There are snips especially designed for circular cutting. They are called CIRCLE SNIPS, HAWKS-BILL SNIPS, TROJAN SNIPS, and AVIATION SNIPS, lined up in figure 51 in that order.



CIRCLE SNIPS



HAWKS-BILL SNIPS



TROJAN SNIPS



AVIATION SNIPS

Figure 51.—Circle, hawks-bill, trojan, and aviation snips.

Use these snips in the same manner as you would use straight hand snips and observe the same precautions. They are made in different sizes.

Circle snips have curved blades and are used for making circular cuts. They are available for either right- or left-hand use.

Hawks-bill snips can cut inside and outside circles of small radii. The narrow curved blades are beveled enough to permit sharp turns without buckling the material.

Trojan snips are slender-bladed snips used for straight or curved cutting. The blades are small enough to permit sharp turns. They will also cut outside and inside curves.

A popular all-around hand snip for aviation technicians is the one at the bottom of figure 51. Snips of this type are known by various trade names, including Bellanca snips and aviation snips. They have narrow cutting blades which are operated by a compound lever action. The lever action enables considerable pressure to be exerted on the blades with less effort being applied to the handles. These snips are used for cutting circles, squares and irregular patterns. The hardened cutting blades make it easier to cut hard material.

Many snips of this type have small serrations or notches on the cutting edges which tend to prevent the snips from slipping backwards when a cut is being made. Although this feature does make the actual cutting much easier, it mars the edges of the metal slightly. You can remove small cutting marks if you allow proper clearance for dressing the metal to size.

There are many other types of hand snips used for special jobs. The snips under discussion here can be used for almost any common type of work.

Learn to use them properly. They should always be oiled and adjusted to permit ease of cutting and to produce a surface that is free from burrs. If the blades bind or are too far apart, the snips should be adjusted.

Oil the entire length of the blade and work machine oil into the adjusting bolt. Open the snips, and tighten or loosen the nut with a small wrench until you have obtained the correct clearance.

#### DRESSING METAL

After you have cut sheet metal to the approximate size, you should dress it to the layout line. Do this with a file. See figure 52. Lay the sheet

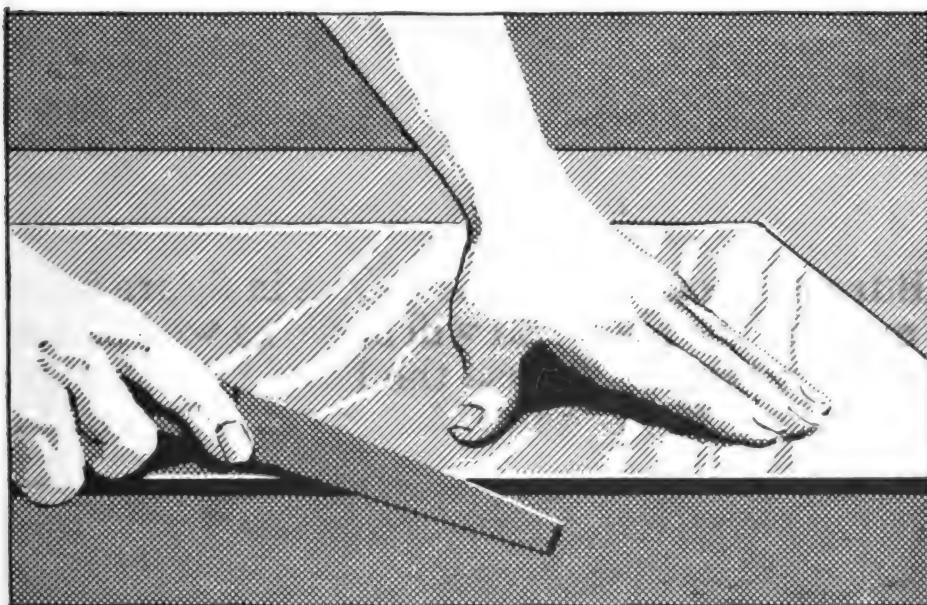


Figure 52.—Dressing metal.

flat on a bench or other support. Make sure that this flat surface is clean and free from any metal particles such as aircraft nails and rivet heads. Careless handling will often cause the sheet to be scratched.

When you have finished dressing the metal to size, there may be burrs, "fins," or ragged edges on the metal. Remove these with either a fine file, a burring tool, or an edge scraper.

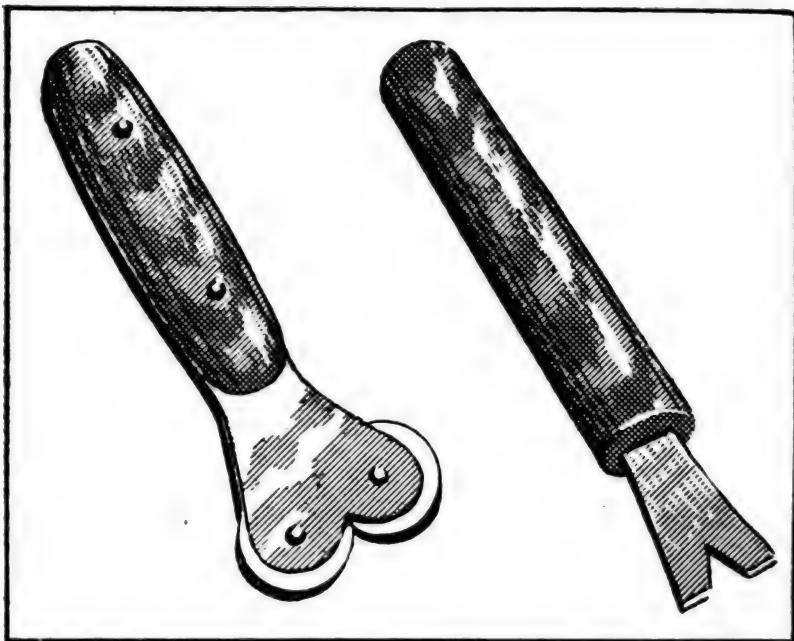


Figure 53.—Burring tools.

Burring tools, like those shown in figure 53, can be made in the shop and will serve as well as more expensive types. To use the burring tool, simply run it along the edge of the metal. Figure 54 is

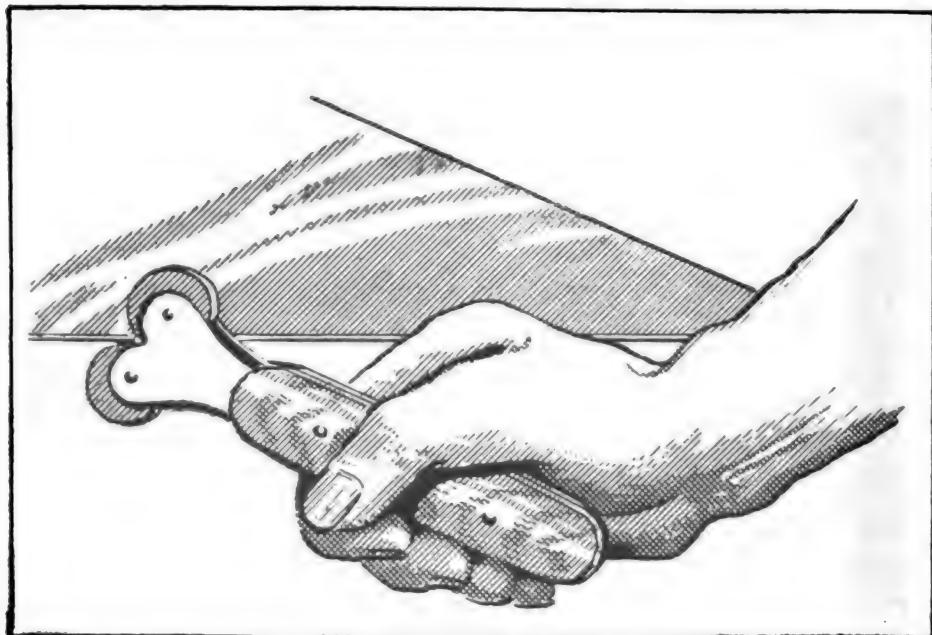


Figure 54.—Burring process.

a good illustration of this process. Once you become familiar with the use of this tool, you will be able to remove burrs from the edge of the metal quickly without marring or scratching the surface.





## CHAPTER 4

### SOLDERING TOOLS

#### WHAT SOLDER CAN DO

Soldering is an easy way of joining two metal parts. The usefulness of the solder process has been demonstrated again and again in the zones of combat, where speed and makeshift are commonly the order of the day.

On one of the islands in the South Pacific several Navy airplanes were grounded by the Commanding Officer because the spark plugs in the planes had done many more than their allowed 60 hours of duty. There were no replacements so the airplanes remained idle.

Finally a shipment arrived. One thousand brand new spark plugs—of the wrong kind! They fitted into the engine satisfactorily but the terminals, which were supposed to receive the electrical connections, were too short and the spark plugs could not be connected.

The somewhat hopeless situation was remedied by ingenuity and SOLDER. Aviation technicians cut off the terminals FROM BOTH THE OLD AND THE NEW SPARK PLUGS. They soldered the terminals from the old spark plugs to the bodies of the new plugs and the grounded airplanes were again ready for fighting action.

### WHAT SOLDERING IS

Soldering is the joining of two metal parts by a metal called solder. Solder is an alloy of lead and tin but has a lower melting point than either of its components and a lower melting point than that of the metals to be joined. Solders which melt readily are SOFT SOLDERS, while those which fuse at a red heat are called HARD SOLDERS.

The process of soldering consists of cleaning the surfaces to be joined, heating them to the soldering temperature by any suitable means such as a soldering copper, a gas flame, or a blowtorch, and applying a flux, which is generally rosin or borax. The flux will remove any grease or oxide present. The solder is then melted into the joint and the joint smoothed over and finished by the use of a soldering copper.

### ALLIED PROCESSES

A process similar to soldering is BRAZING. Principal difference—brazing requires the use of a harder filling material called spelter, which is generally a mixture of copper, zinc, and tin. In brazing, the parts to be joined are cleaned carefully. The flux is applied, and the parts clamped in position for joining. The parts are heated and the molten spelter is “flowed” (by capillary attraction) into the space between the parts and allowed to cool slowly.

**SILVER SOLDERING** is a form of low-temperature brazing in which the solder may be a high-percentage silver alloy. Silver soldering gives greater joint strength than soft soldering. Soldered joint strength is limited to the strength of the solder, which is almost always lower than that of the parent metal. Soldering is restricted to metals such as copper, tinware, galvanized sheet iron, lead, and zinc.

### **SOLDERING COPPERS**

Soldering coppers, sometimes **INCORRECTLY** referred to as soldering irons, are used mostly for small soldering work. Made of copper, these tools must be "tinned," or coated with solder, and maintained in a clean condition before they can be used efficiently.

Tinning consists of filing the surface of a soldering copper to a bright and smooth finish, heating it to a temperature sufficient to melt solder, rubbing the surface of the copper on a block of sal-ammoniac and then applying a small portion of solder and rosin to the copper's surface. This process will form a tinned surface on all sides. A soldering copper is used in soldering sheet metals together where the sheets are either lapped or locked together and present a surface over which the soldering tool may be drawn.

The tool is heated to a temperature sufficient to quickly melt the solder and is drawn along the edges to be joined at such a rate that the momentary high temperature of the edges, together with the quickly molten state of the solder, allows the formation of a tight waterproof seal. The soldering copper is also used in work where there is a fire hazard and the use of a flame or molten solder poured over the surface is prohibited.

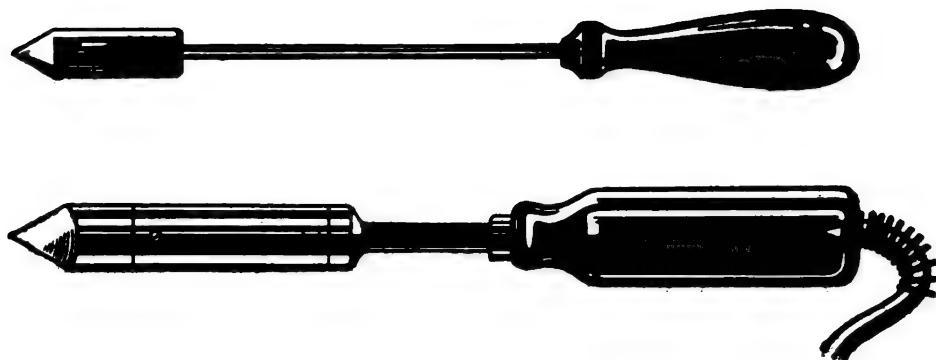


Figure 55.—Soldering coppers—plain and electric.

Soldering coppers may be heated by a blowtorch, gas flame, or electricity. Electrically heated soldering coppers are special types, with the heating coil built internally. Both types are illustrated in figure 55.

The point or working face of a soldering copper should be relatively blunt. The purpose of the copper is to transmit heat. If it is too thin and sharp, it will cool too rapidly. Use a large soldering copper wherever possible, as it will hold heat longer.

#### THE BLOWTORCH

Where the metals to be joined are not flat surfaces in position for the use of a soldering copper, soldering is accomplished by playing the flames of a gasoline, kerosene, or alcohol blowtorch directly on the surfaces and then applying the solder cold in bar or wire form of small cross sections. The heated surfaces melt the solder.

The gasoline blowtorch, pictured in figure 56, is the one most commonly used in soldering. Its operation is simple.

Fill the tank about two-thirds full of clean, unleaded gasoline. Operate the pump until sufficient pressure is built up in the tank to cause the gasoline to flow when the valve is opened.

With the valve open, liquid gasoline will flow

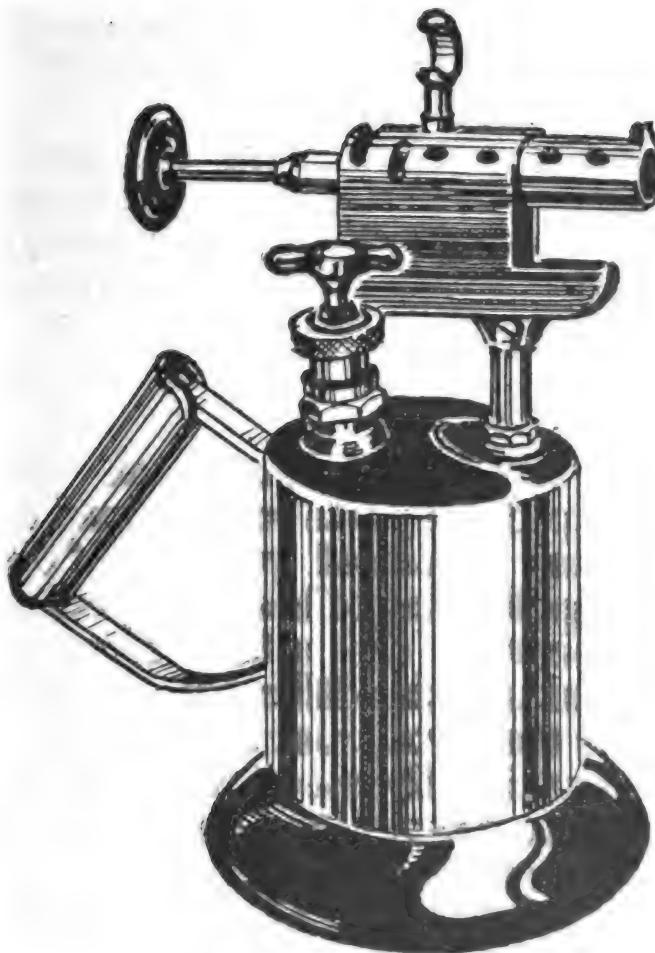


Figure 56.—Gasoline blowtorch.

from the jet of the torch and drip into the priming pan. When the pan is partly full, close the valve and ignite the gasoline with a match. The flame from this burning gasoline heats the perforated nozzle (or heating tube). When the nozzle is hot, open the valve slightly again, allowing the gasoline vapor which has been formed to flow from the nozzle. It burns with an almost colorless flame. By working the valve, you can adjust this flame to any desired intensity.

There is very little maintenance to the gasoline torch providing you use ONLY CLEAN, CLEAR, UNLEADED GASOLINE. If you use leaded gasoline, a compound will form that will stop up the gasoline

passages. The torch will be a source of trouble from then on as it is almost impossible to clean these passages thoroughly.

Don't close the valve with too much force. Remember, the metal is hot and will contract when it cools, thus causing the valve to tighten up when cold. If you use too much force, it will be difficult to reopen the valve.

### FLUX

Solder will stick only to clean metal. Even after you have scraped the parts to be joined until they shine, there may be a small quantity of dirt on the metal. The application of heat will produce oxides which will prevent the solder from adhering. FLUX will eliminate this difficulty. It retards oxidation, cleans the metal, and aids fusion.

The fluxes ordinarily used for soft soldering are solutions or pastes that contain zinc chloride. The solvent or other medium holding the flux material is evaporated by the heat of the soldering operation, leaving a layer of the solid flux on the work. At the soldering temperature, the solid flux is melted and partially decomposed with the liberation of hydrochloric acid. This acid then dissolves the oxides from the surfaces of the solder and the work. The melted flux also forms a protective film on the work that prevents further oxidation from taking place.

Because zinc chloride fluxes have a corrosive action, it is sometimes necessary to employ a non-corrosive flux for work where the last traces of the flux cannot be removed after the soldering is completed. Rosin is the most commonly used flux of this type.

Various fluxes are used when soldering different kinds of metal. Zinc chloride will clean and prevent oxidation when black iron is being soldered.

Another flux, muriatic acid, is the commercial form of hydrochloric acid and is yellow in color. This raw acid is used as a flux when soldering galvanized iron but it is a good practice to add a little zinc to the raw acid to prevent blackening of the galvanized iron around the soldered joint. Rosin is used as a flux on new tin plate because it is noncorrosive. Rosin acts only to prevent oxidation and does not clean the tin plate. Therefore, raw acid must be used to clean old tin plate, while rosin is used for the actual soldering.

METAL	FLUX
Black Iron	Zinc Chloride
Galvanized Iron	Muriatic Acid
Tin Plate	Rosin





## CHAPTER 5

### DRILLING AND REAMING TOOLS

#### DRILLS AND DRILLING

The hand drill, breast drill, and brace, shown in that order in figure 57 are the common hand tools for holding and turning drills. You can drill holes in metal by hand up to  $\frac{1}{4}$  inch in diameter. The actual cutting of the hole is done by a twist drill. This efficient tool does its work by slicing metal away from the pointed center as it rotates. Look at figure 58 for an illustration of a twist drill and its parts. Twist drills are made either of carbon steel or high-speed steel. If carbon steel is heated excessively and allowed to cool it will lose its hardness.

High-speed steel, on the other hand, has the property of "red hardness." It can become red-hot without losing its temper. For any drilling at high speed, therefore, use high-speed steel twist drills to obtain best results and lasting cutting effectiveness.

The three principal parts of twist drills are the body, the shank, and the point. They are available

with either two, three, or four flutes. Flutes are the spiral grooves formed along the sides. Drills having three or four flutes are used to follow smaller drills or to enlarge cored holes. They are not suitable for drilling into solid stock. These spiral flutes give twist drills several definite advantages.

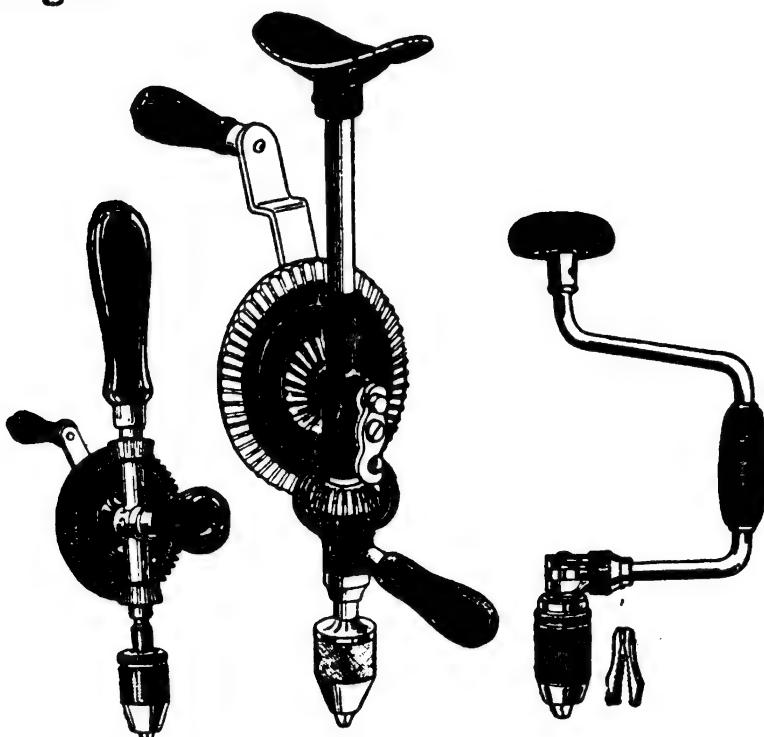


Figure 57.—Hand drill, breast drill, and brace.

They give a correct rake to the lips, as shown in figure 59. They cause chips formed while drilling to curl tightly so that they occupy the minimum amount of space. They form channels through which such chips can escape from the hole, and they allow the lubricant, when one is used, to flow easily down to the cutting edge of the drill.

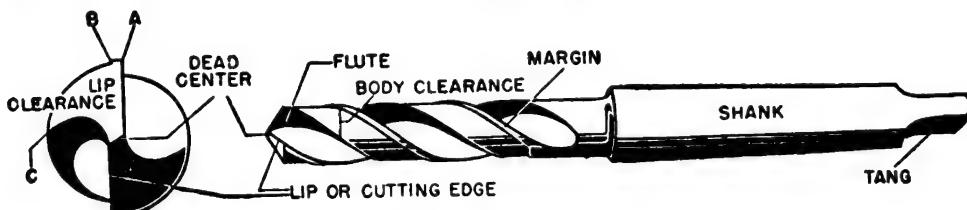


Figure 58.—The twist drill.

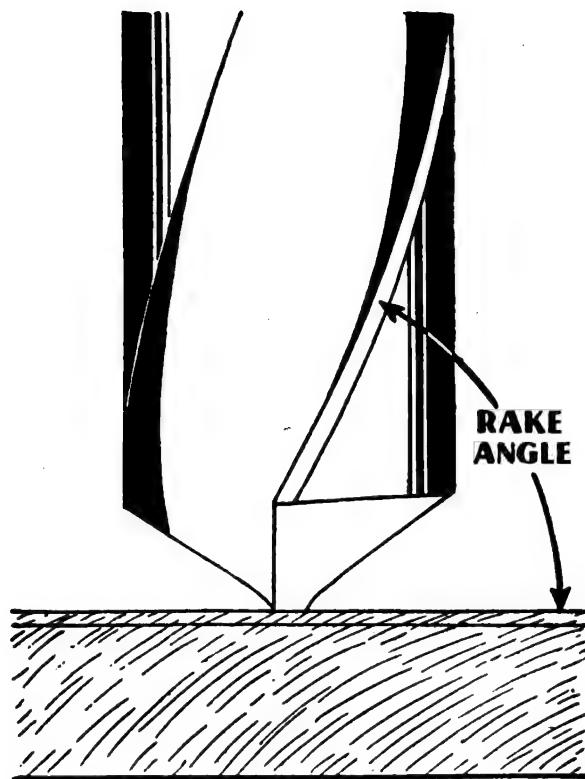


Figure 59.—Rake angle.

The drill shank is the end that fits into the chuck of the hand drill. In figure 60, the two shapes of shank commonly used for hand drilling are shown. The straight shank is generally used in hand,



STRAIGHT SHANK



BIT-STOCK SHANK

Figure 60.—Types of drill shanks.

breast, and portable electric drills. The square or bit shank is made to fit into a brace.

Drill sizes are designated under three heads—  
Numerical, No. 80 to No. 1 (0.0135 to 0.228  
in.).  
Alphabetical, letter A to Z (0.234 to 0.413  
in.).  
Fractional,  $\frac{1}{64}$  to 1 in. and over by 64ths.

### USE OF HAND DRILLS

Some materials do not require a lubricant when drilling. Others require a lubricant peculiar to their nature. The following table may be used as a guide:

Tool steel—oil.  
Soft steel—oil or soda water.  
Wrought iron—oil or soda water.  
Cast iron—dry.  
Brass—dry.  
Copper—oil.  
Babbitt—dry.  
Glass—turpentine.

### PILOT HOLES

When drilling hard material, it is good practice to drill a pilot hole first about half the size of the diameter you desire. Then follow this pilot hole with a drill of the proper diameter.

### TESTING DEPTH

When you want to drill a hole ONLY PART WAY through the work, you can get an approximate measurement of the depth by inserting a piece of dowel rod, a pencil, or the stem of a match into the hole. Then measure the length of the inserted part. If extreme accuracy is required, you should use a DEPTH GAGE.

## THE ELECTRIC DRILL

Drilling holes in metal with an electric drill is similar to drilling by hand except that the power for turning the drill is furnished by an electric motor instead of by the operator.

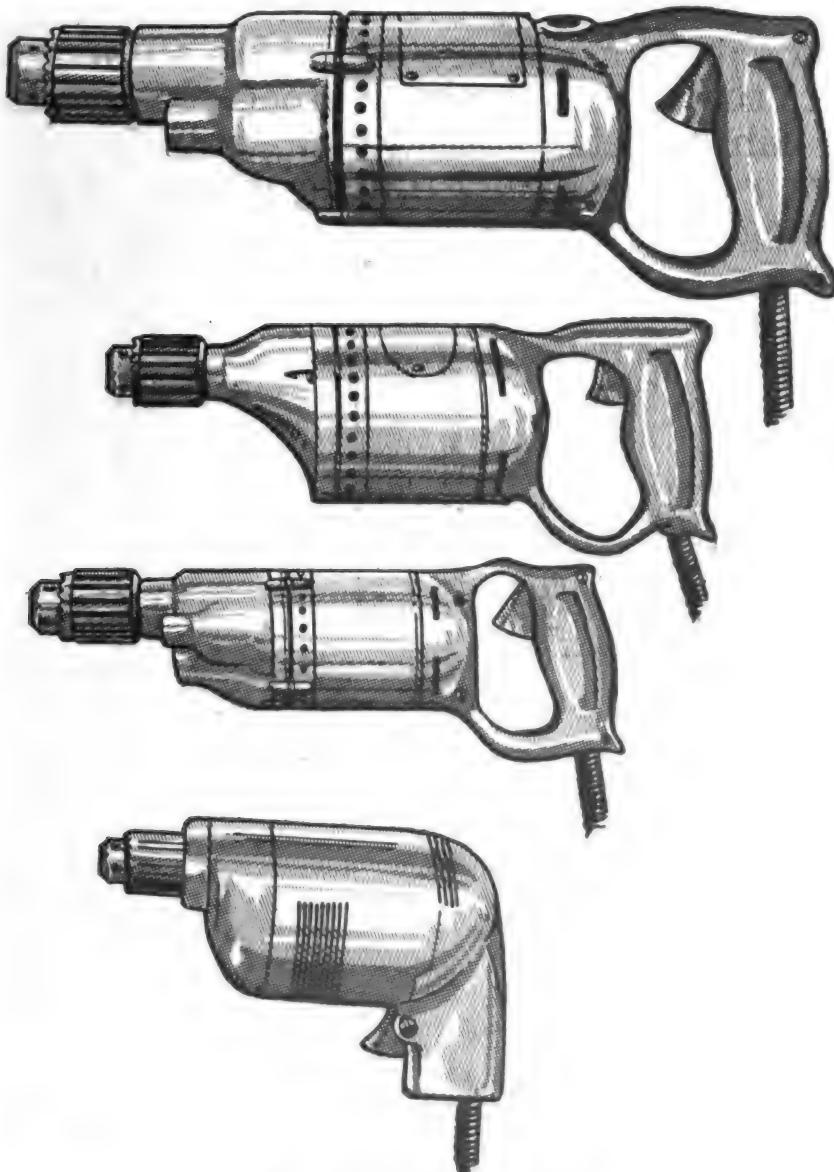


Figure 61.—Electric drills.

Electric drills used for aviation work have capacities for drilling holes in steel from  $\frac{1}{16}$  to  $\frac{1}{2}$  inch in diameter. Although there are many dif-

ferent designs of electric drills, most of them are similar to the popular types shown in figure 61. Some drills are equipped with pistol grip or space (closed) handles. Larger drills usually have an extra handle so that they can be held in both hands. Ordinarily, straight shank twist drills are used in electric drills. They are secured in a key-type geared chuck (see figure 62) which automatically centers the drill shank in the tool. Many electric drills can be fitted with attachments for driving screws, rotating small grinding wheels, drilling at right angles, and so on.

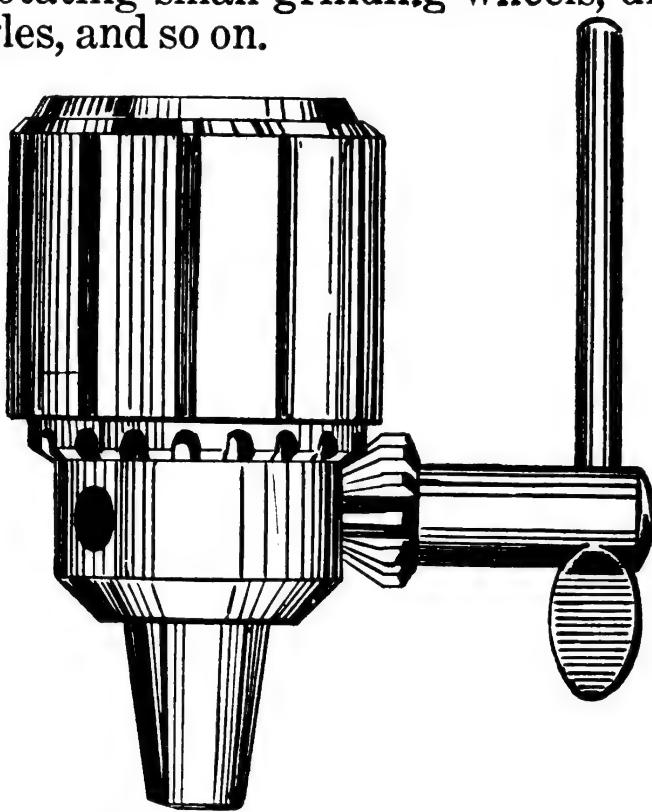


Figure 62.—Key-type gear chuck.

A few words about the chuck. It is the clamping device on the end of the drill into which the twist drill is inserted. Chucks are manufactured in sizes corresponding to the sizes of the drills with which they are used.

To set the twist drill in the chuck, place the shank of the twist drill in as far as possible between the three jaws and tighten with the chuck key.

## HOW TO USE THE ELECTRIC DRILL

Be sure that the diameter of the hole to be drilled is within the capacity of the tool. Electric drill sizes usually indicate the largest diameter the tool will drill in steel. For example, a  $\frac{1}{2}$ -inch electric drill is intended to drill holes up to and including  $\frac{1}{2}$ -inch in diameter, AND NO LARGER. If it is used for a  $\frac{5}{8}$ -inch hole, for instance, the work will overload the motor. It is better practice to use a drill having a larger capacity than actually necessary.

Mark the exact location of the hole to be drilled and start it with a center punch, exactly as when you are drilling by hand.

Select a proper size twist drill that is sharp and straight, insert the twist drill in the chuck, and tighten it securely with the chuck key. Then, WITH THE MOTOR RUNNING, insert the point of the drill into the punch mark and start drilling. Hold the electric drill properly at a  $90^{\circ}$  angle to the surface at the marked spot. If the drill is not at right angles to the work, the hole will not be straight.

If the hole goes through the work, relieve the pressure when the point of the drill begins to break through. After the hole is completed, withdraw the drill from the hole, pulling it STRAIGHT BACK, and then shut off the motor. You should remember that twist drills do not pull themselves into the work. They must be fed by pressure. You must exert this pressure exactly the same way as if you were drilling entirely by hand. The only effort you will save by the electric drill is that of TURNING. You also save a lot of time.

### THINGS TO REMEMBER—

The drill must be supported properly to prevent walking and chuck-marring of materials.

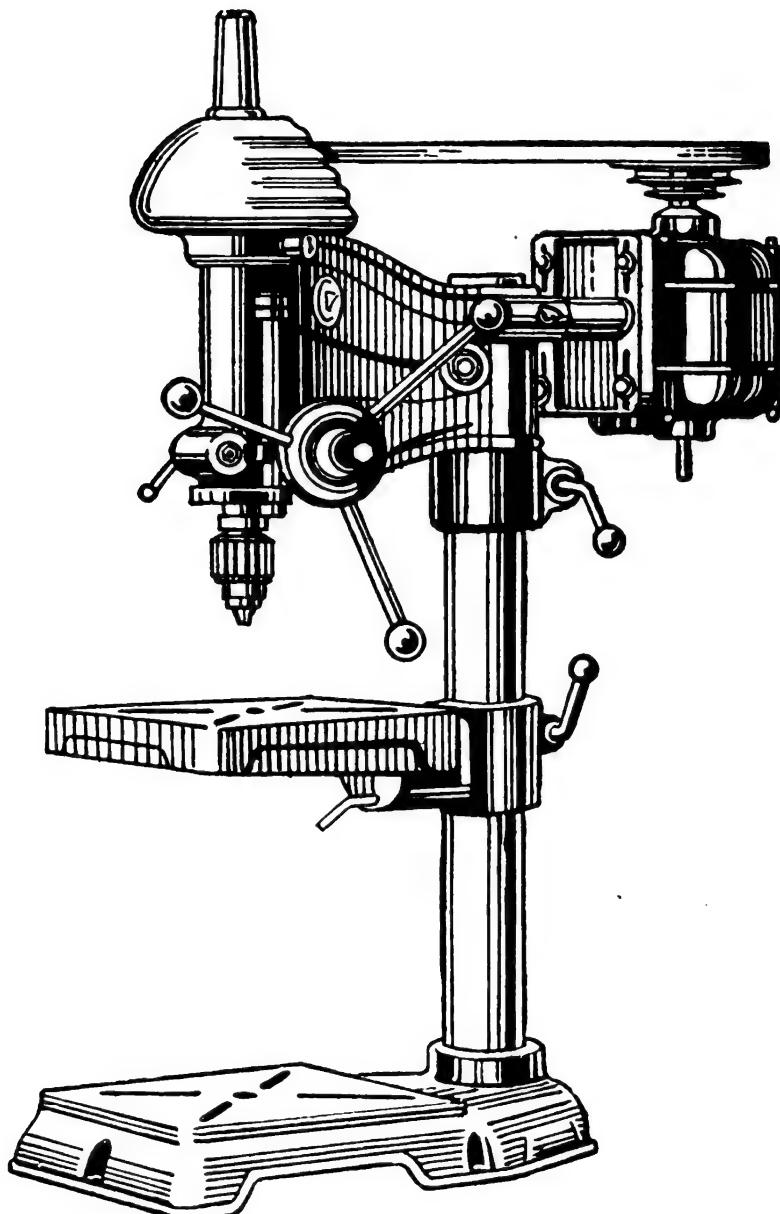
**Do not allow the drill to continue running in the hole. It will enlarge the hole.**

**Never hold the material you are drilling in your hands.**

**Drill correctly. Poor and incorrect drilling is the greatest cause of scrap.**

**Be sure the work is held rigidly.**

### **THE DRILL STAND**



**Figure 63.—Stand for electric drill.**

The drill stand will aid you to accurately locate and maintain the direction of a hole to be drilled. It also provides you with an easy control for feeding the drill into the work. A common type of drill stand is shown in figure 63 with a  $\frac{1}{2}$ -inch-capacity electric drill fitted to it. A lever is provided on this stand so you can feed the drill into the work with either very heavy or comparatively light pressure. When you use a drill stand, place the work on the table and bring the tool down on it by means of the handle. Locate the spot to be drilled directly under the drill. Fasten the work securely to the table with clamps. Feed the drill into the hole by means of the lever. Use sufficient pressure to cut, but not enough to cause the drill to overheat or the motor to stall.

#### POINTS GROUND AND SHARPENED

Drills should be correctly ground and sharpened. Unless your drill is in proper working condition, it will make a hole that is rough or off size.

The points involved in grinding are dead center, point, heel, lip-clearance angle, margin, body clearance, and web.

The dead center is the sharp chisel edge at the extreme tip end of the drill. It is formed by the intersection of the cone-shaped surfaces of the point and should always be in the exact center of the drill's axis.

The point of a drill is the ENTIRE cone-shaped surface at the cutting end. Do not confuse it with the dead center.

The heel of a drill is the part of the point back of the lips or cutting edges.

The lip-clearance angle is the angle at which the drill point is ground off just back of the lips.

The margin is the narrow strip which extends the entire length of the flutes. It is the full diameter of the drill. Actually, the margin is part of a cylinder that is interrupted by the flutes.

The part of the drill back of the margin is of slightly less diameter than the margin. The difference is known as BODY CLEARANCE. This clearance reduces the friction between the drill and the walls of the hole. The margin insures the hole being the right size.

The web is the metal column which separates the flutes. It runs the entire length of the drill between the flutes, gradually increasing in thickness toward the shank.

#### GRINDING THE LIPS OR CUTTING EDGES

Both lips of a twist drill should be the same length and ground to a  $59^{\circ}$  angle for work in aluminum, steel, and cast iron, as shown in figure 64.

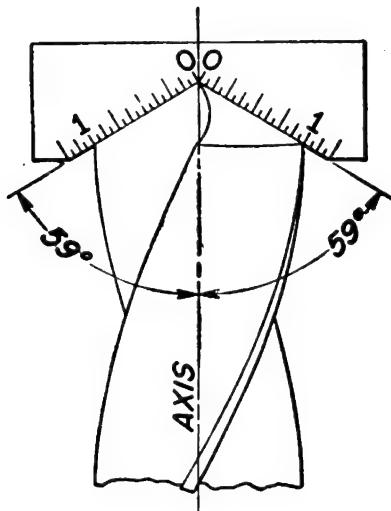


Figure 64.—Correctly ground drill lips.

If the angle is more than  $59^{\circ}$ , the point will be too flat to center properly. If it is less than  $59^{\circ}$ , the hole will be drilled less rapidly than it should be, and more power will be required to drive the drill.

If the point is on center but the cutting edges ground at different angles, the drill will bind on one side, only one lip will do the work, and the hole will be larger than the drill.

### GRINDING THE LIP-CLEARANCE ANGLE

The heel of the drill, that is, the surface of the point back of the cutting lips, should be ground away from the cutting lips at an angle of from  $12^{\circ}$  to  $15^{\circ}$  at the circumference of the drill, as shown in figure 65.

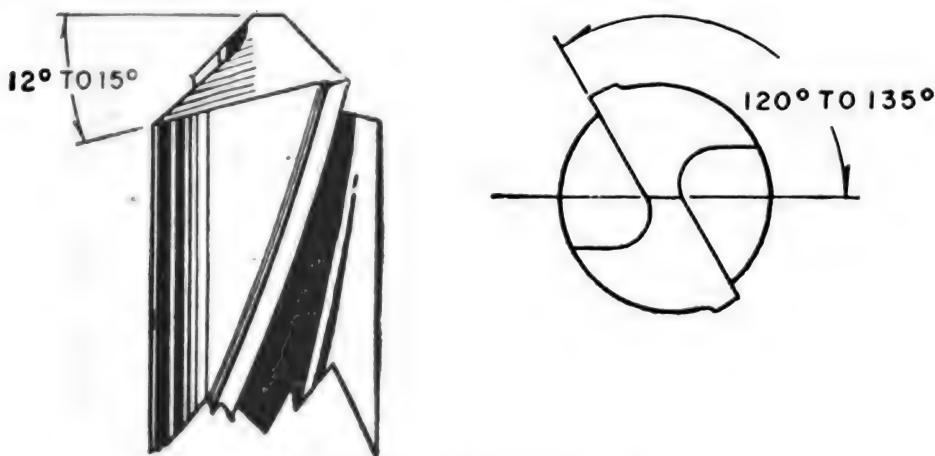


Figure 65.—Lip-clearance angle.

There are one or two common mistakes to avoid in grinding the lip. If you do make them, you will

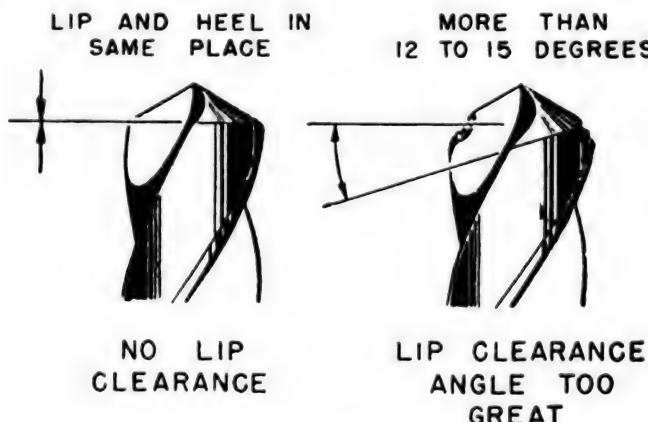


Figure 66.—Results of incorrect lip-clearance grinding.

get results similar to those shown in figure 66. For instance, when the cutting point is central but the angles of the cutting edges are different, the drill will bind on the side of the hole opposite the lip which is cutting. It will drill too large a hole and the work will all be done by one cutting edge. Or, if the point is ground with equal angles but with the cutting edges of different lengths, the point will no longer be central and the drilled hole will be oversize.

### THE RAKE ANGLE

The rake angle of a drill is the angle of the flutes in relation to the work. It is usually between  $22^{\circ}$  and  $30^{\circ}$ . If this angle is too small, it makes the cutting edge so thin it may break under the strain of the work. The rake angle also partly governs the tightness with which the chips curl and the amount of space they occupy. Cast iron chips do not curl.

Like many other tools used in aircraft work, the supply of electric drills and repair parts is critically short. Hence, you must take the best possible care of those now available. As these tools are in almost constant operation, a reasonable degree of wear is expected. However, neglect and carelessness in their use is inexcusable.

Most electric drills are cased in light weight cast aluminum alloy housings and are likely to crack or break if struck against any object that is more solid. Never allow them to swing by the cord or place them in a position where they might fall.

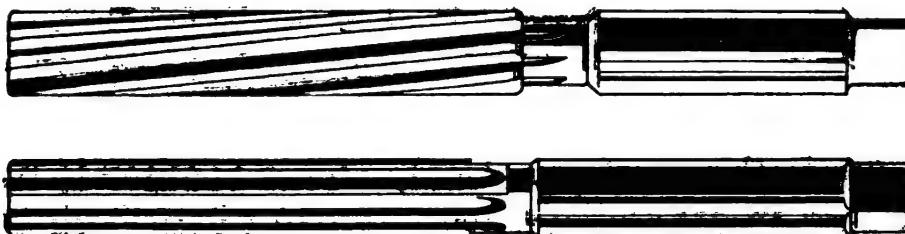
Do not oil an electric drill unless cocks for that purpose are built in the housing. Do not remove the plug while the motor is running. Worn brushes cause a flashing within the motor but do not always stop the operation. For best performance, worn brushes should be replaced.

**Do not lay a drill down while it is running and don't use damaged plugs or receptacles.**

The cable or "cord" is the insulated flexible line which transmits the current to the motor. The cable should never be pulled, knotted, or looped. Neither should it be left where it might be crushed between objects or by the weight of moving machines. Do not carry the motor suspended by the cable. **CAUTION!** Never leave a cable suspended where someone may trip over it.

## **REAMERS**

Ramers are used to enlarge and true a hole. The reamer consists of three parts—the body, the shank, and the blades. The shank has a square tang to allow the reamer to be held in a tap wrench, or other similar handles, for turning. The main purpose of the body is to support the blades.



**Figure 67.—Above—solid spiral flute reamer.**

**Below—solid straight flute reamer.**

The blades on a reamer are made of steel and hardened to such an extent that they are brittle. For this reason you must be careful in using and storing the reamer to protect the blades from chipping. When you are reaming a hole, turn the reamer in the CUTTING DIRECTION ONLY. This will prevent chipping or dulling of the blades. Great care should be used to assure even, steady turning. Otherwise, the reamer will "chatter," causing the hole to become marked or scored. To prevent dam-

age to the reamer while not in use, wrap it in an oily cloth and keep it in a box.

Rreamers of the types shown in figure 67 are available in any standard size. They are also available in size variations of .001" for special work. Use a solid straight flute reamer when reaming holes of the same size. This type lasts longer and is less expensive than the expansion reamer.

The solid spiral flute reamer is also used where many similar holes are to be reamed. Many mechanics prefer it because it is less likely to chatter. The spiral reamer costs slightly more than the straight flute reamer.

For general purposes, an expansion reamer, fig-

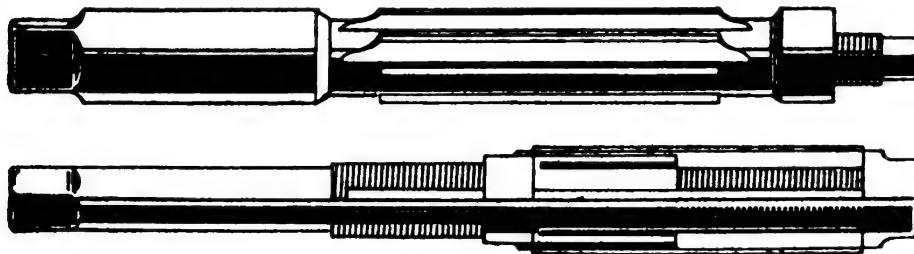


Figure 68.—Expansion and adjustable flute reamers.

ure 68, is the most practical. This reamer is usually sold in standard sizes from  $\frac{1}{4}$  of an inch to 1 inch, by 32nds. It is designed to allow the blades to expand  $\frac{1}{32}$  of an inch. For example, the  $\frac{1}{4}$ -inch expansion reamer will ream a  $\frac{1}{4}$ -inch to a  $\frac{9}{32}$ -inch hole. A  $\frac{9}{32}$ -inch reamer will enlarge the hole from  $\frac{9}{32}$  of an inch to  $\frac{5}{16}$  of an inch. This range of adjustment allows a few reamers to cover the entire field. If you use them carefully they will meet almost any need.

Rreamers are made of carbon steel and high-speed steel. In general, the cutting blades of a high-speed reamer lose their keenness quicker than a good carbon steel reamer. However, after that keenness is gone it will last longer than the carbon reamer.

## COUNTERSINKS

Countersinks are used to bevel the edge of a drilled hole.

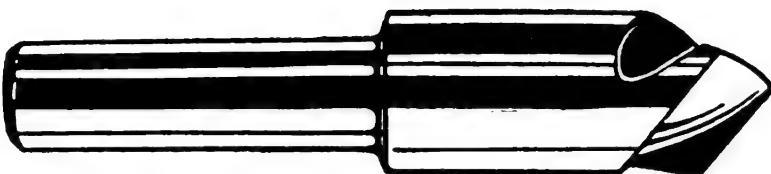


Figure 69.—Countersink.

The type of countersink shown in figure 69 is used commonly. Its construction is similar to the twist drill. There are three cutting edges, which are taper-ground to the angle marked on the body.

Countersinks are made in a number of sizes. One size usually takes care of holes of several different sizes. That is, the same countersink can be used for holes from  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch in diameter. Remove only enough metal to set the screw or rivet head flush with the material. If you remove too much material the hole will enlarge and weaken the work.

Select the countersink with the correct lip angle to correspond with the screw or rivet head being used. These countersinks can be used in portable hand drills, bench drill presses, or the common hand brace.

If, in an emergency, a countersink is not available, use a twist drill about twice the size of the hole. DO NOT REMOVE TOO MUCH MATERIAL. A twist drill will cut faster and have a tendency to "dig in" more than the countersink. If necessary, the lip angle of the twist drill can be changed to fit the need.





## CHAPTER 6

# THREAD-CUTTING TOOLS

### RUSH ORDER

There's a story about a well-meaning but inexperienced clerk who discovered that his company's order for bolts had not been filled. He wrote a note to the manufacturing company demanding some quick action on the unfilled order for bolts. The company answered politely that the bolts were cut to length but had not been threaded. To which the clerk replied—"Well, send along the bolts anyhow and ship the threads whenever they are ready."

Now screw threads, as you know, form a ridge of uniform section in the shape of a spiral or helix on the surface of a cylinder or cone. There are EXTERNAL and INTERNAL threads, the difference being whether the thread has been cut on the outside or inside of a member. For instance, a threaded plug is an external thread—that is, the thread is on the outside. A threaded hole is an internal thread—the thread is on the inside.

Threads also have DIAMETERS. The major di-

**d**iameter, formerly known as the outside diameter, is the largest diameter of the thread forming helix, and the minor diameter is the smallest diameter of the thread forming helix. "Minor diameter" used to be called **CORE** diameter if applied to the thread of a bolt or plug and **INSIDE** diameter if applied to the thread of a nut.

The **PITCH** diameter is the diameter of an imaginary cylinder on a straight (untapered) screw thread. The surface would pass through the threads about midway between the major and minor diameters—or more accurately, at such points as to make equal the widths of the solid portions of the threads and the widths of the spaces cut by the surface of the imaginary cylinder.

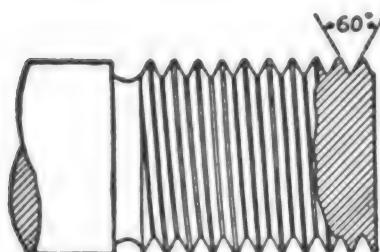
## TWO OTHER THINGS YOU SHOULD KNOW—

**PITCH** is the distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis.

**LEAD** is the distance a screw thread advances axially in one turn.

## THE THREAD SERIES

The National Screw Thread Commission has authorized two series of standard screw pitches. These are the AMERICAN NATIONAL "FINE" (N. F.) and the AMERICAN NATIONAL "COARSE" (N. C.) thread series.



### AMERICAN NATIONAL SCREW THREAD (Formerly U. S. Standard Screw Thread)

#### FORMULA

$$P = \text{Pitch} = \frac{1}{\text{No. Th'ds. Per In.}}$$

$$D = \text{Depth} = P \times .64952$$

$$F = \text{Flat} = \frac{P}{8}$$

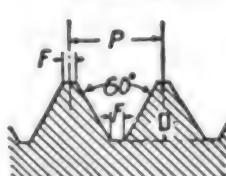


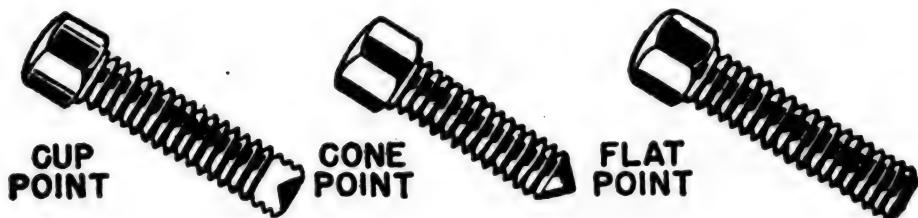
Figure 70.—American National Screw Thread.

The form of thread is the same for both the National Fine and the National Coarse threads. The only difference is the pitch or number of threads to the inch. The American National Screw thread is pictured in figure 70.



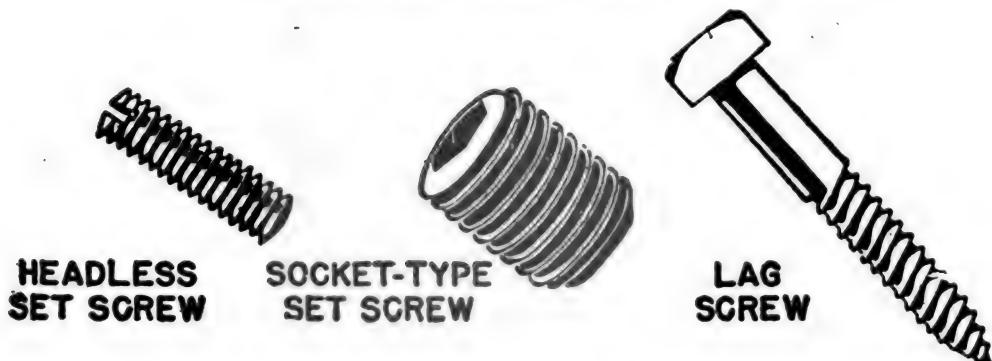
HEXAGON HEAD      FLAT HEAD      BUTTON HEAD      FILLISTER HEAD

### CAP SCREWS



CUP POINT      CONE POINT      FLAT POINT

### SQUARE HEAD SET SCREWS



HEADLESS  
SET SCREW

SOCKET-TYPE  
SET SCREW

LAG  
SCREW



FLAT  
HEAD



ROUND  
HEAD



oval  
head



FILLISTER  
HEAD

### MACHINE SCREWS

Figure 71.—Types of screw heads and points.

The N. C. thread series is used primarily for general engineering work where rapid and easy assembly is desired. The N. F. series is used generally in automotive and aircraft work where parts must be securely held in place. In addition to these standard coarse and fine threads, there are a few special thread pitches. They are called NATIONAL SPECIAL (N. S.) screw threads.

There are four different classes of fits for the above-discussed screw threads. They are called loose fits, free fits, medium fits and close fits. The loose fits are recommended as a commercial standard for tapped holes in the numbered (small) sizes only, and also for rough work when ease of assembly is desirable and snugness of fit is unnecessary.

Free fits are used for the great bulk of screw thread work of ordinary quality of finished and semi-finished nuts and bolts. Medium fits include the better grade of interchangeable screw thread work, such as automobile and aviation nuts and bolts. Close fits are used for work which requires a fine screw fit.

Several different types of machine screws are shown in figure 71. The flat head and round head machine screws are the ones you will use in Naval aircraft work.

Pipe threads are used on the fittings of various fuel and oil piping systems. Threads for these fittings must conform to the National Screw Thread Commission standards. Pipe threads are made either straight or tapered. The taper for tapered pipe threads is 1 to 16 inches, or  $\frac{1}{16}$  of an inch to an inch. It's easy to confuse taps and dies for pipe threads with tap and dies for screw threads. But don't do it!

## TAPS AND DIES

Taps and dies are tools for cutting screw threads. You'll use taps to cut internal threads and dies to

cut external threads. Learn how to cut good threads with these tools. Taps and dies are pigeon-holed according to the type of thread they form—such as N. F. or N. C.—OR according to the diameter of the screw formed, or to fit a hole that is tapped, or according to the number of threads to the inch.

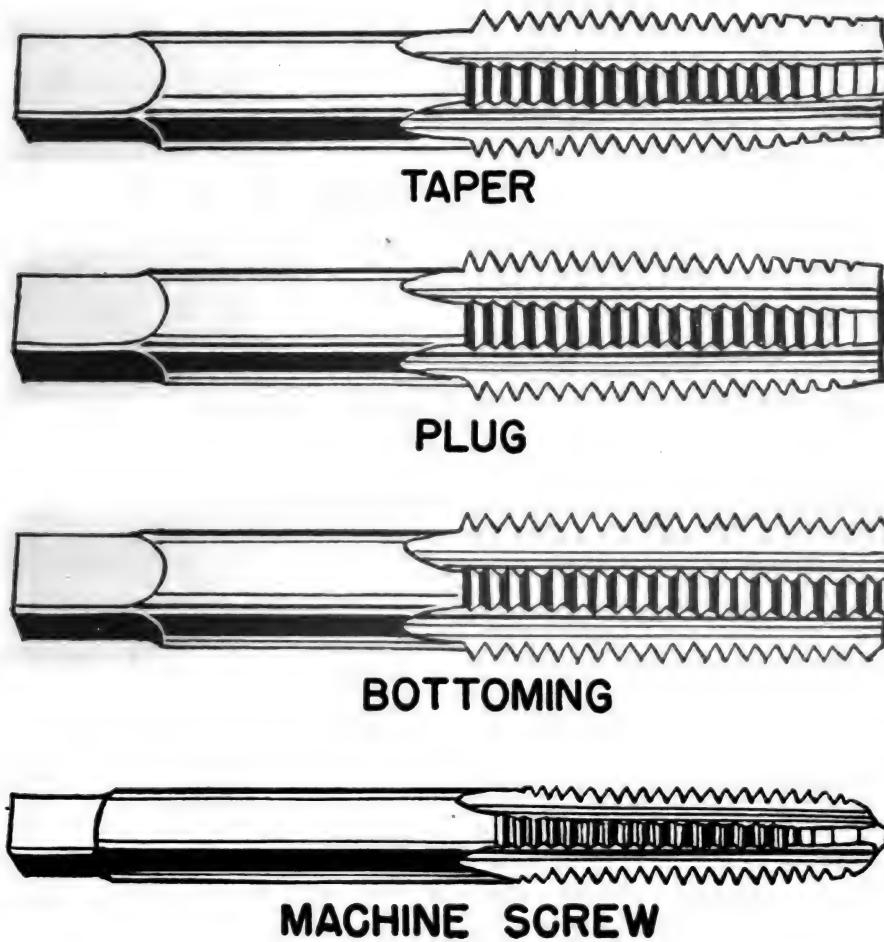


Figure 72.—Hand taps.

Taper, plug, and bottoming taps for screw threads usually come in a set. See figure 72. They make one size of thread. The taper tap may be used for internal threading where the work permits the tap to be run entirely through. The diameter of this tap gradually increases from or near the starting end.

When the taper tap cannot be run through the work, you will notice that—near the bottom of the tapped hole—the diameter will be so small that the screw or bolt will not screw down as far as it should. In this case, run in a plug tap after the taper tap is removed. If you want full diameter threads all the way to the bottom of the hole, follow the plug tap with a bottoming tap which is the same diameter its entire length.

Dies are made in a variety of forms but the adjustable round split die shown in figure 73 is the Navy standard. When you are cutting threads

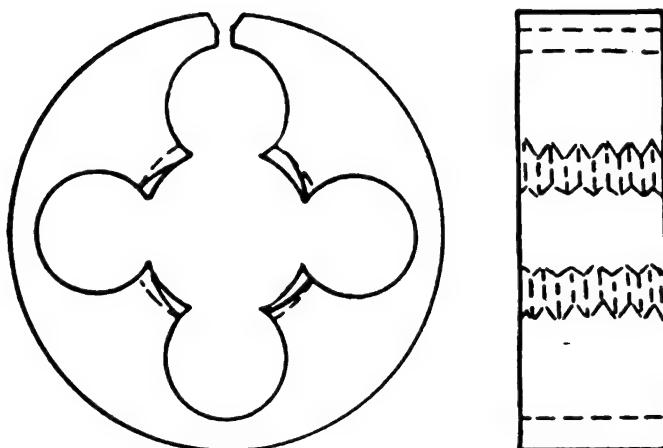


Figure 73.—Adjustable round split die.

with a die, the thread will be formed progressively, if you adjust the die after each cut. Each cut produces a slightly deeper thread until the finished thread is obtained.

Each die is made in one piece. The adjustment is made by splitting the die between two of its lands (cutting portions between grooves) and expanding or contracting it. Don't confuse adjustable round

split dies for thread cutting with hexagon rethreading bolt dies. Hexagon rethreading bolt dies have six cutting lands and are intended for dressing over bruised and rusty threads.

There are many forms of wrenches for turning taps, and stocks for turning dies. The diestock for adjusting round split dies, and the T-handled and adjustable tap wrenches, shown in figure 74, will enable you to work either in open or confined spaces.

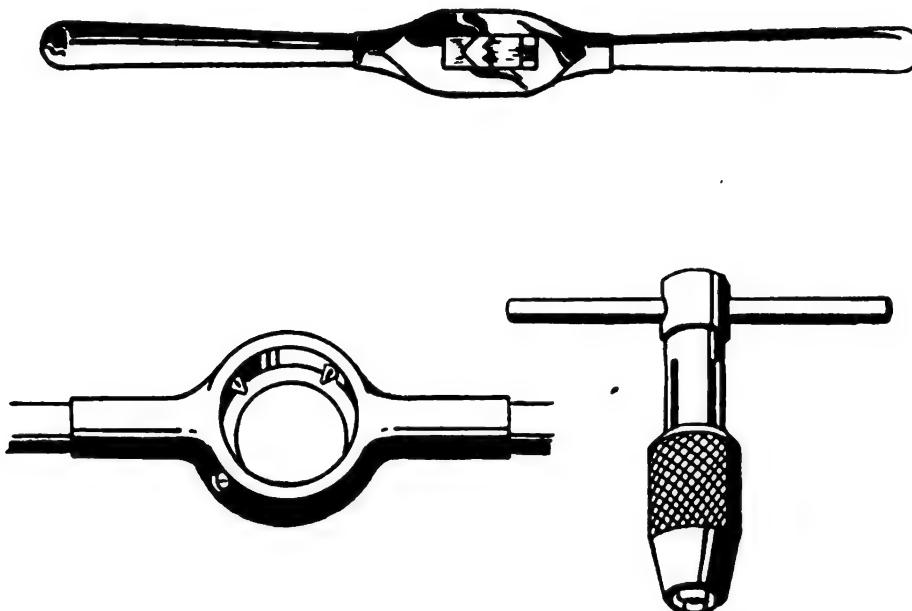


Figure 74.—Diestock and wrenches.

The size drill for drilling a hole to be threaded is determined by the diameter of the tap minus one and one-half times the depth of the thread used. A skilled mechanic can judge the size drill to use on rough work—a feat you can accomplish with enough experience. A fact you might remember is that taps and dies used in making the National Standard screw threads cannot be used in making the National Taper pipe thread.

If you use a lubricant in cutting threads, it will insure a smooth, clean-cut thread. Lard oil is generally preferred on steel, kerosene is used on alu-

minum or aluminum alloy. A lubricant is not needed on brass. There are left-handed taps and dies for making left-hand threads, just in case you were wondering.

## SCREW EXTRACTOR

It is not difficult to remove a broken stud-bolt, machine screw, set screw, or other threaded members from a tapped hole IF you use the right method.

Designed especially for this purpose are screw extractors, like the one shown in figure 75. To remove a broken stud, first drill the stud as in figure 75. The drill should be about  $\frac{3}{4}$  of the

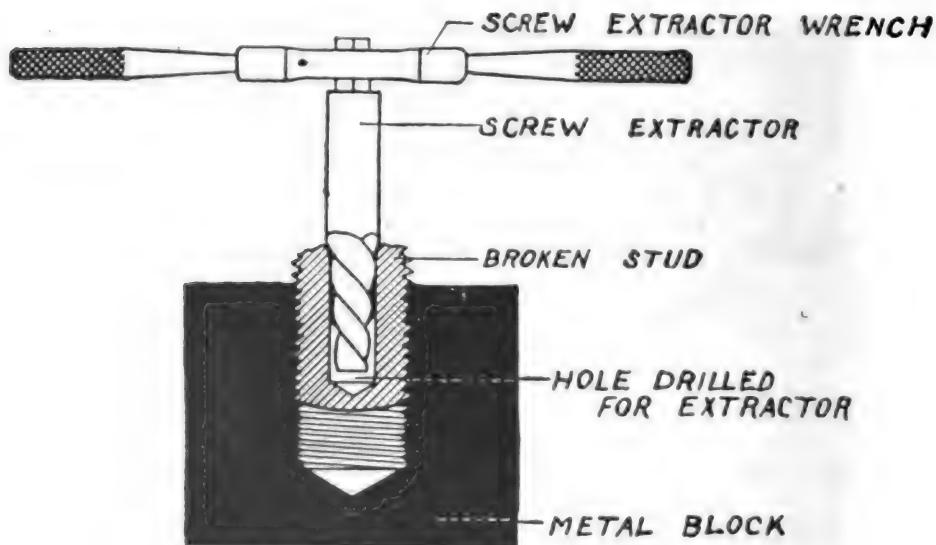


Figure 75.—Using the screw extractor.

stud's diameter. After drilling, insert the extractor and tap it LIGHTLY into position. Be extremely careful not to strike the extractor too hard. It has already been hardened to the point where it is quite brittle and a heavy blow would more than likely cause it to break.

After setting the extractor, put a wrench on its square shank. Holding a down pressure on the extractor, turn it gently to the left. The stud

should start turning WITH the extractor. All you have to do is continue turning it out. If the stud refuses to turn with the extractor—STOP, put some penetrating oil on the threads, wait a few moments and try again. Don't put a lot of pressure on the extractor thinking that a little force will budge the stud. It won't—it will only break the extractor.

If the broken stud protrudes above the surface, it can sometimes be removed by using a small wrench. However, if it does not respond immediately to a reasonable pull on the wrench, you'd better try to free the screw threads by applying a penetrating oil. Then strike the end of the broken screw with light blows of a hammer.

There may be times when you can remove a broken stud by sawing a screw driver slot in the broken end of the stud shank and then removing it with a screw driver.





## CHAPTER 7

### TUBING FABRICATING TOOLS

#### TUBING CUTTING

Something new has been added to tube cutters. They are now furnished with a specially processed cutting wheel of the highest grade high-speed steel. This wheel will cut carbon and stainless steel tubing as well as copper, brass, and aluminum alloy tubing.

Figure 76 will aid in the explanation of tube cutting tools. The cutter shown is a type that is used a great deal. To operate it, place the tubing between the rollers and the cutting wheel. Screw down the cutting wheel LIGHTLY against the tubing at the point where you want to cut the tubing. Then rotate the cutter around the tube, still maintaining a light, even pressure on the cutting wheel by means of the screw adjustment. The proper direction of rotation is with the handle of the cutter moving toward the open side, as shown by arrows in figure 76.

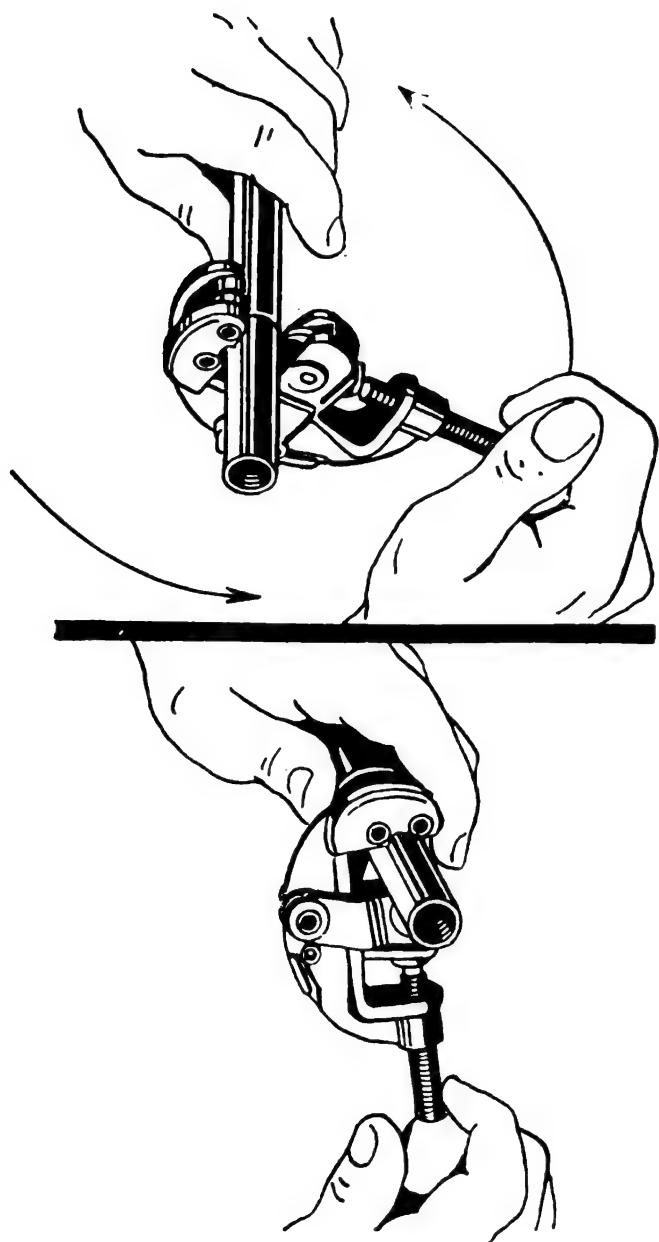


Figure 76.—Tube cutting tool.

This method of cutting tubing is much better than using a hacksaw. For one thing, it insures perfectly square ends with no external burrs and little internal burring.

#### FLARING TOOL

Essential to any installation of seamless tubing is a GOOD FLARING JOB. The efficiency and con-

venience of a flared type joint is determined by the manner in which the tubing is flared, or spread at the end. For this important reason, **MAKE FLARES CLEAN AND OF THE CORRECT FORM AND SIZE.**

Before starting any flares, be sure the tube is cut off straight, square, and smooth. A perfectly round tubing cross-section must be maintained. The tubing must also be free from all burrs, scratches, nicks, or other surface defects.

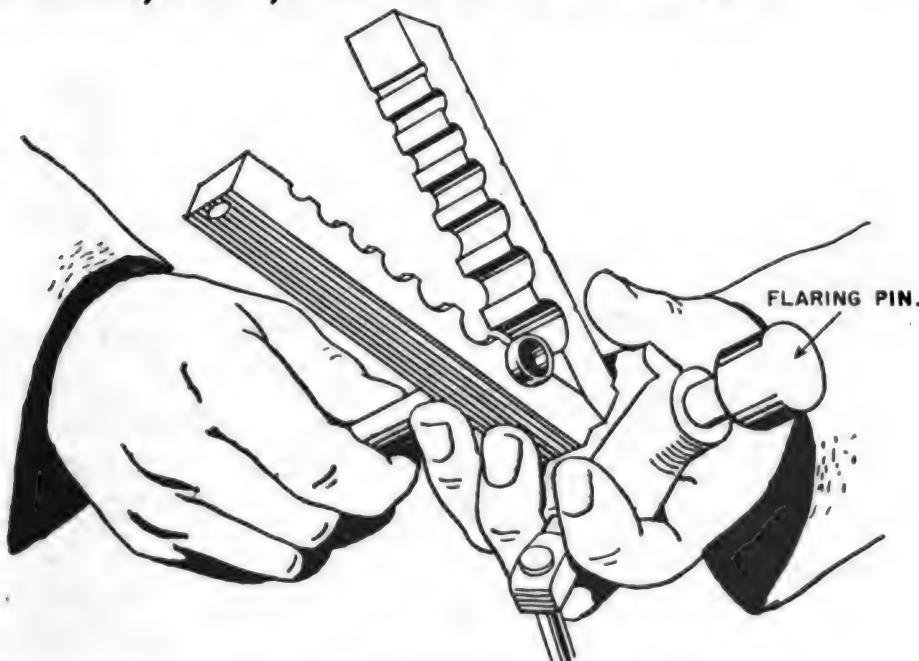


Figure 77.—Combination flaring tool.

The combination flaring tool is shown in figure 77. To use it correctly, first clamp the tubing securely in the flared hole THAT FITS, with the end of the tubing flush or slightly above the surface. Move the flaring pin over the tube and strike a number of light blows with a hammer until the tubing is properly flared. Rotate the flaring pin between blows—it will give you an even pressure throughout the flare. You're bound to make mistakes in flaring when you begin and only by experience can you become efficient in the correct flaring procedure. BUT, you can exercise caution and that will save a lot of trouble.

## COMMON MISTAKES YOU CAN AVOID

If the flares are too long, too short, or not straight, mistakes have been made. The results of three incorrect jobs are shown in figure 78.

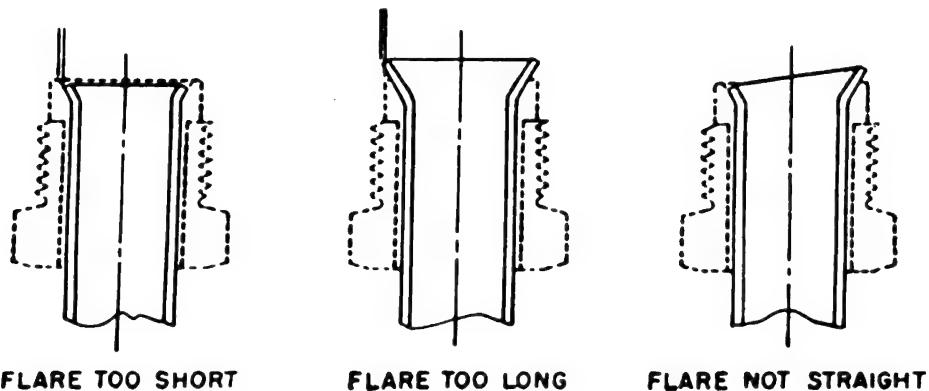


Figure 78.—Flaring mistakes.

On tubes flared too short, the full clamping area of the fitting is not utilized. Because of the small area of the tube that is clamped, the flare may be squeezed thin. Such joints do not offer maximum security against pull-out strains, or leakage and breakage at the flare.

Tubes flared too long will stick and jam on the threads during assembly. They are likely to seat against the bottom of the coupling instead of the tapered seat. Uneven flares, no matter which way you look at it, are the result of carelessness. Either the tube end has not been cut squarely or the flaring is so haphazardly done that the flare is not concentric with the tube. Such flares are not aligned with the fitting seating surfaces and must be de-formed into a tight seat. This will eventually cause failure of the fitting.

### TOOLS FOR TUBE BENDING

There are several devices available which make it possible to bend tubing without kinking or flattening it. The simplest of these is merely a coil

of steel wire. The inside diameter of the coil must be the same as the outside diameter of the tube to be bent. In making the bend, slip the coil over the section of tubing to be shaped. Form the proper curvature with your hands. After the bend is made, remove the coil by twisting and pulling at the same time.

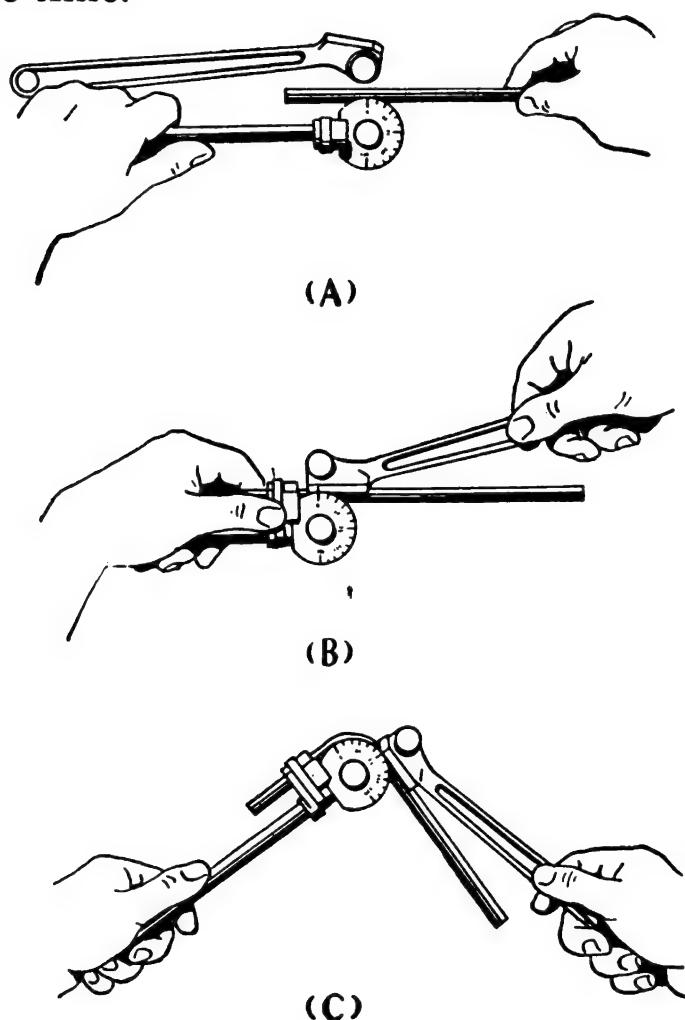


Figure 79.—Parker hand tube bender.

The use of a Parker hand tube bender is illustrated in figure 79. Suppose that you've placed the bending tool on the bench with the scaled side of the sheave block up, the round handle extending to the left, and the flat handle to the right. It will look like *B* in figure 79. Then if you swing the flat

or right handle up toward the left as far as it will go, and lift the tube retaining clip under your left thumb, the tube bender will be in the position shown in *A*.

Place the section of the tube to be bent in the position shown in *A*. Drop the retaining clip over the tube and pull the flat handle around to the position shown in *B*. The index mark on the back end of the flat handle will line up with the zero degree mark on the sheave block. Then pull the flat handle around as shown in *C* until the mark on the block end of the flat handle reaches the desired degree mark on the sheave block. Illustration *C*, for instance, has a reading of 90 degrees. To remove the tube, bring the flat handle back to the position shown in *A* and lift the tube out.



## CHAPTER 8

### MEASURING TOOLS

#### STEEL RULES

Length is the measure of the distance from one point to another. Tools used to measure length are graduated in inches, feet, or fractional parts. The inch is used for small measurements, and the foot for large measurements.

The most common tools and devices used for the measurement of length are STEEL RULES of different sizes and names such as hook rule, folding steel rule, flexible steel rule and tape, divider, and trammel points.

When you take measurements you will use steel rules ranging in size from one to more than 36 inches. The one in your tool kit is probably a 6-INCH RULE. Look at the section of this rule illustrated in figure 80. Notice that on each of the edges of this rule, the inch is divided into different fractional parts. This provides four separate scales graduated in eighths, sixteenths, 32nds, and 64ths. Use the edge graduated in the largest fractional part of an inch required by the measurement. For instance, if you want to measure a distance of  $3\frac{3}{16}$  of an inch, use the edge graduated in sixteenths. To measure a distance of  $3\frac{3}{64}$  of an inch, use the edge graduated in 64ths.

If you glance at the HOOK RULE shown in figure 81, you will discover that it is simply a steel rule with a hook or projection on one end. It comes in different lengths and widths. On some models

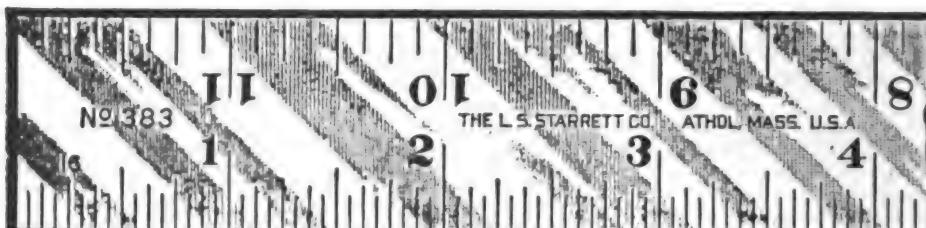


Figure 80.—Steel rule.

the hook can be removed when it is not being used. This hook is attached to the rule so that its inner edge lines up with the end of the rule.

Maybe your mind asks the question, "What advantage does this hook have?" It comes in handy when you want to line the rule up to a rounded edge or when you can't tell by looking at a surface whether the rule is even with the edge from which the measurement is to be taken. If you ever have to measure the distance through bolt holes, or the length of holes through pulleys, you will find a narrow hook rule very valuable.

All you have to do is hook the end over the work. The measurement to another point is indicated on the scale.

You have often seen places where small steel



Figure 81.—Hook rule.

rules with HOLDERS, such as those shown in figure 82, were needed. You will find them valuable in measuring out-of-the-way places or measuring to a shoulder or a projection. The handle is arranged so that the rule can be clamped at various angles.

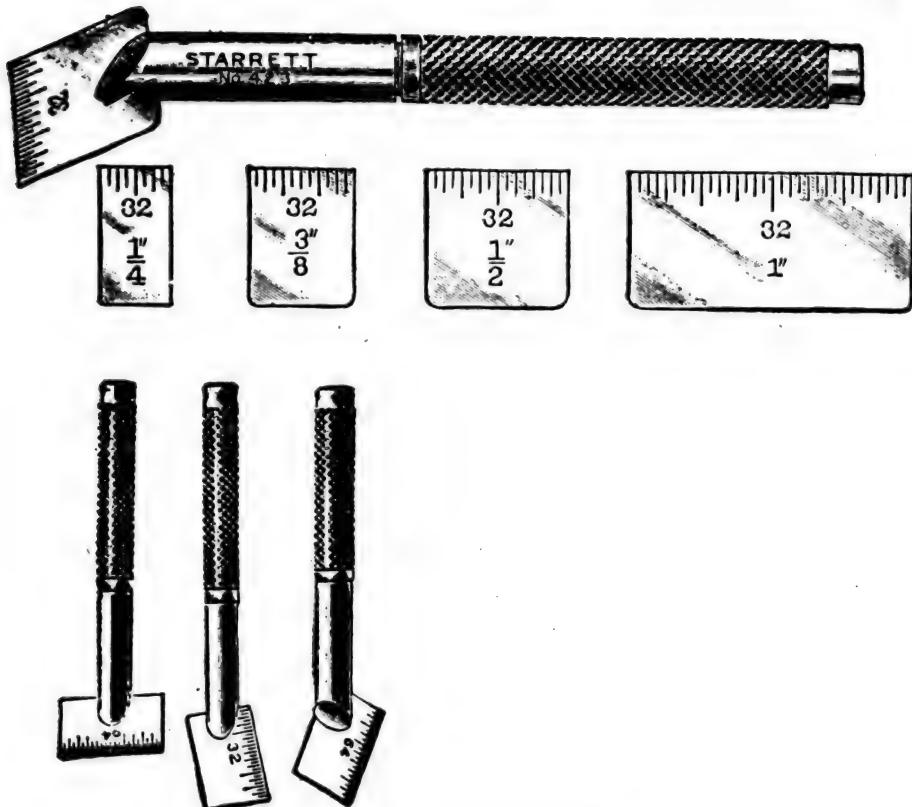


Figure 82.—Rule with holder.

These rules can be removed and replaced easily and quickly.

You really don't have to look twice at the FOLDING STEEL RULE in figure 83 to know why it has an

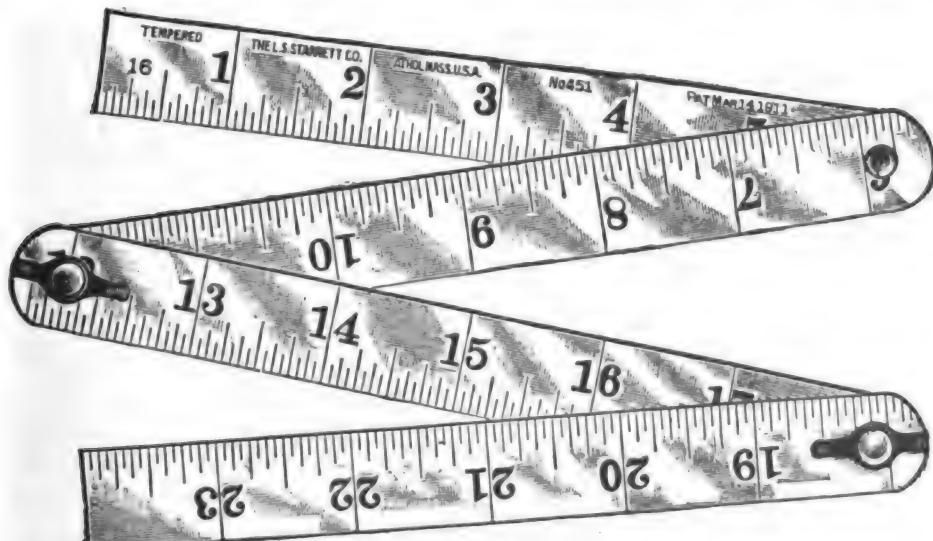


Figure 83.—Folding steel rule.

advantage over the long, single-piece rule. You can fold this rule to a compact size and stow it conveniently. Although, for the most part, you will be using the 6-foot size, you can obtain these rules in lengths from 2 to 6 feet.



Figure 84.—Flexible steel rules.

The FLEXIBLE STEEL RULE in figure 84 is called "the last word in measuring devices." You will find a great many uses for it in aircraft work.

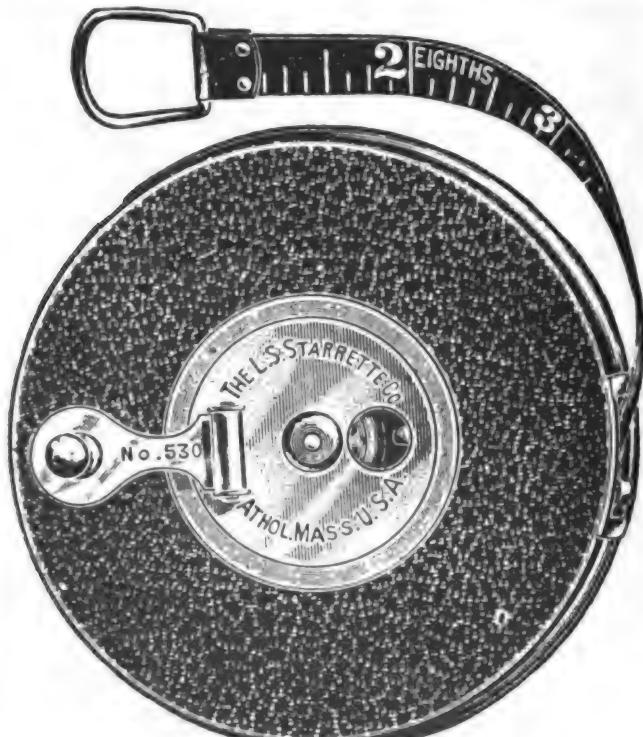


Figure 85.—Flexible steel tape.

They are extended easily or coiled in their cases for stowage, and you can conveniently carry one of these in your pocket. Another thing, they are not as bulky to handle as the large steel tapes.

You have to pull the FLEXIBLE STEEL TAPE, shown in figure 85, from its case by hand. When you want it back in the case, wind it with a crank. Tapes of this type are long, flexible steel rules, usually furnished in 25- and 50-foot lengths.

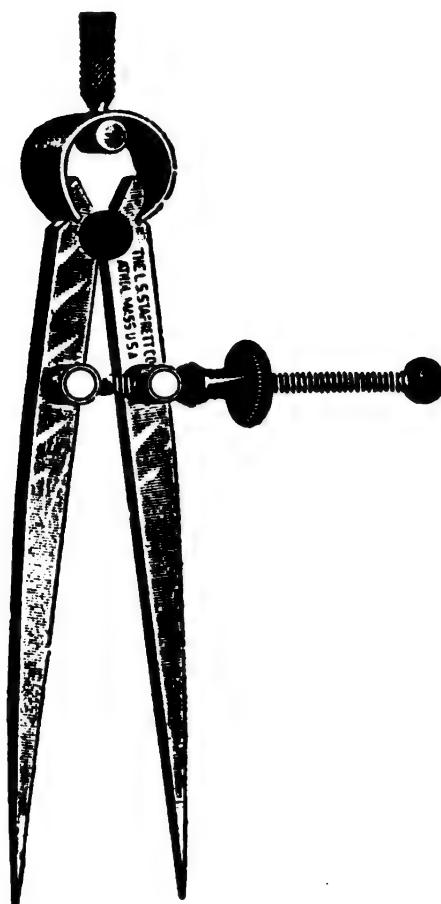


Figure 86.—Dividers.

The kind of DIVIDERS you will use is shown in figure 86. They are used with a rule in the measurement of length to transfer measurements from the work to the rule and vice versa. Frequently, you will use dividers in scribing circles and arcs in layout work.

Sometimes when you are measuring wires in the rigging of aircraft, you will use TRAMMEL POINTS similar to those shown in figure 87. You can check the length of brace wires with them. You can use the ball points shown with the trammel points when working from holes in sheet metal where the regular point would be ineffective. The ball end centers the trammel point over the hole.

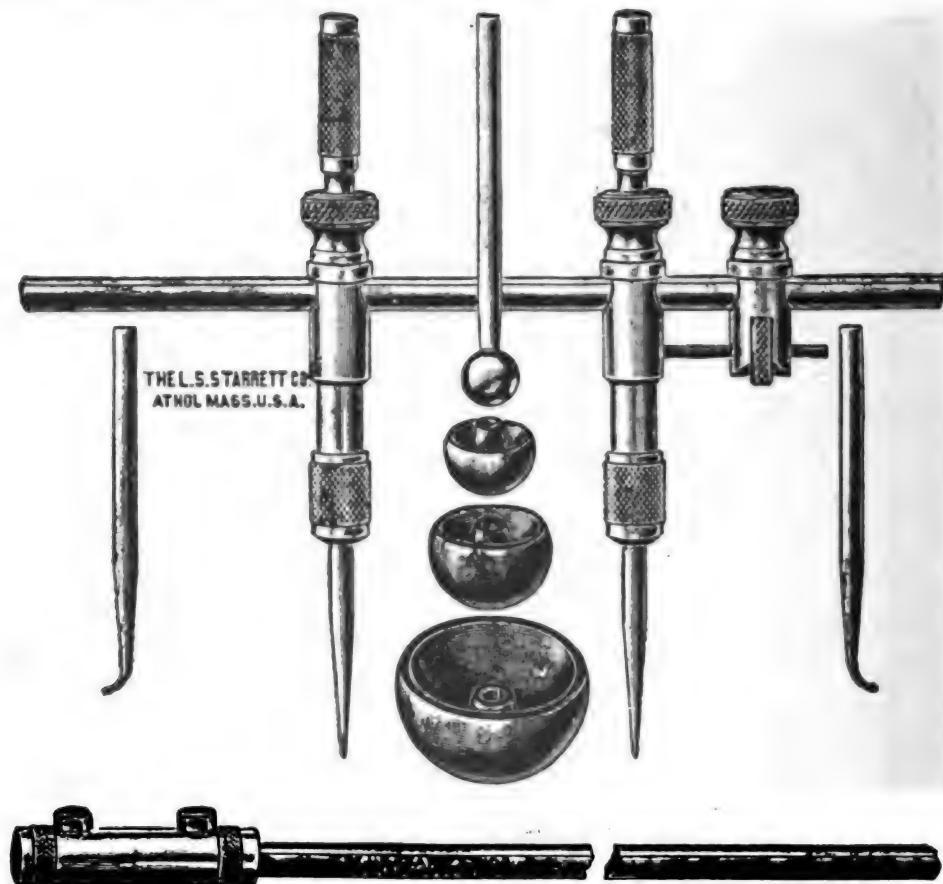


Figure 87.—Trammel points.

#### MEASURING THICKNESS AND OUTSIDE DIAMETERS

Tools used for measuring thickness and outside diameters include the caliper rule, outside calipers, micrometer caliper, drill gages, wire gages, sheet-metal gages, and so on.

You will find that the CALIPER RULE is convenient for measuring small rods, tubing, bolts, and sheet

stock. Clamp the object you want to measure between the end of the rule and the contact arm.

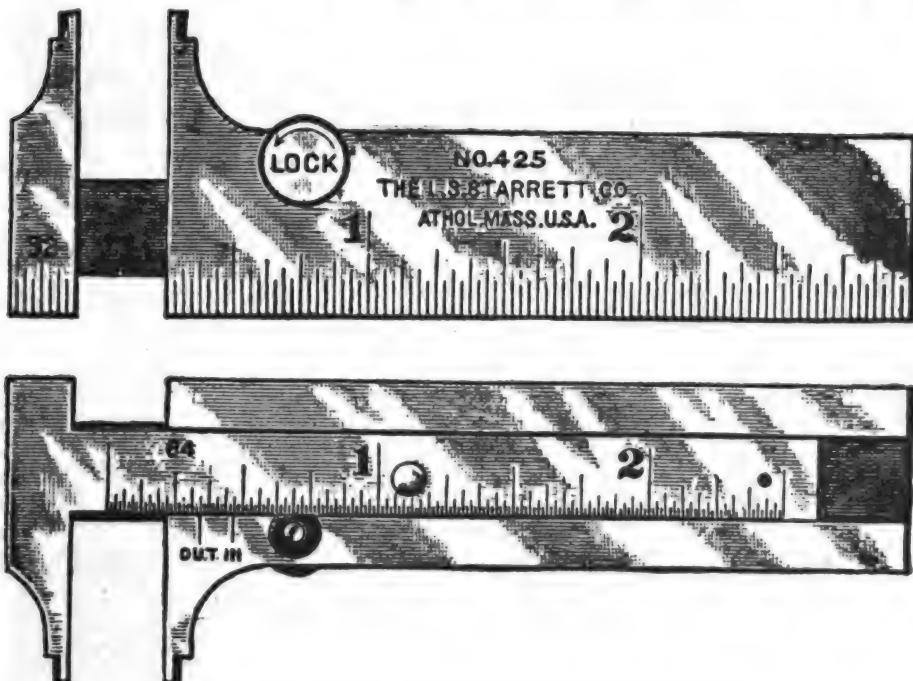


Figure 88.—Caliper rules—inside and outside.

Read the sliding arm to get the size of the object. Note that in addition to the standard graduations on the face, the caliper rule also has a graduated sliding arm. Some caliper rules can be used for taking inside measurements. Both inside and outside types are shown in figure 88.

You will frequently use the type of OUTSIDE CALIPERS illustrated in figure 89. When you want to determine outside diameters or the thickness of material or parts, use the outside calipers and a rule or gage. You can set the calipers to an opening by turning the knurled adjusting screw.

#### MICROMETER CALIPER

You know the value of accuracy and you know that, in order to be accurate, you must have tools to aid you. One of the most efficient tools in many a tight spot is the micrometer caliper shown in figure 90.

The micrometer caliper illustrated here is the outside type which you will use to measure the outside diameter or thickness of an object. These micrometer calipers are precision instruments, made in many sizes, and designed to measure accurately diameters or lengths.

Study figure 90 carefully, and learn the names of the various parts of the tool. The spindle and the thimble are in one piece so that the spindle is moved forward or back by turning the thimble clockwise or counterclockwise.

If you are to measure the size of any piece, turn the thimble until the anvil and spindle form a contact with the object. Its size is then indicated by the exposed figures on the sleeve plus those shown on the beveled section of the thimble.

After the spindle is brought into contact with the object to be measured, the speeder and friction slip at the end should be turned. A ratchet stop is connected to the speeder inside the instrument

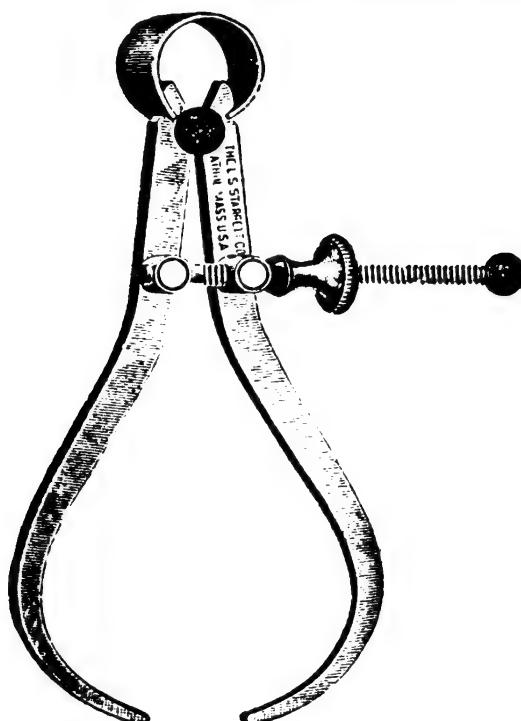


Figure 89.—Outside calipers.

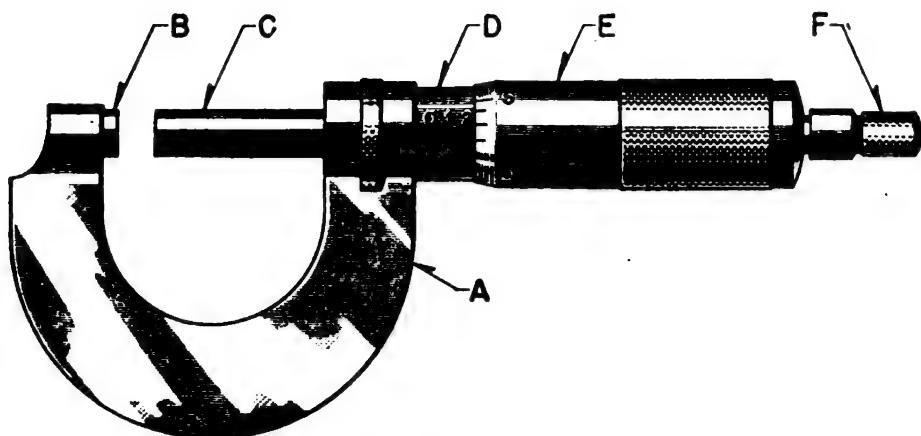


Figure 90.—Micrometer caliper.

A. Frame.  
B. Anvil.  
C. Spindle.

D. Sleeve.  
E. Thimble.  
F. Friction slip.

so that the spindle is always brought into contact with the object at the same pressure. This is a guard against personal error—especially when several measurements have to be taken by a number of men.

### MICROMETER SCALE

The sleeve and thimble of the micrometer caliper have been enlarged in figure 91. The threaded section on the spindle that revolves in the fixed nut has 40 threads per inch. Every time the thimble completes a revolution, the spindle advances or recedes  $\frac{1}{40}$ " or .025".

The horizontal line on the sleeve is divided into 40 equal parts per inch. Every fourth graduation is numbered 1, 2, 3, 4, etc., representing .100", .200", etc. When you turn the thimble so that its edge is over the first sleeve line past the "0" mark, and coincides with the "0" on the thimble scale, the spindle has opened .025". If you turn it to the second mark, the spindle has moved .025" plus .025" or .050". You use the scale on the thimble when the edge of the thimble falls between grad-

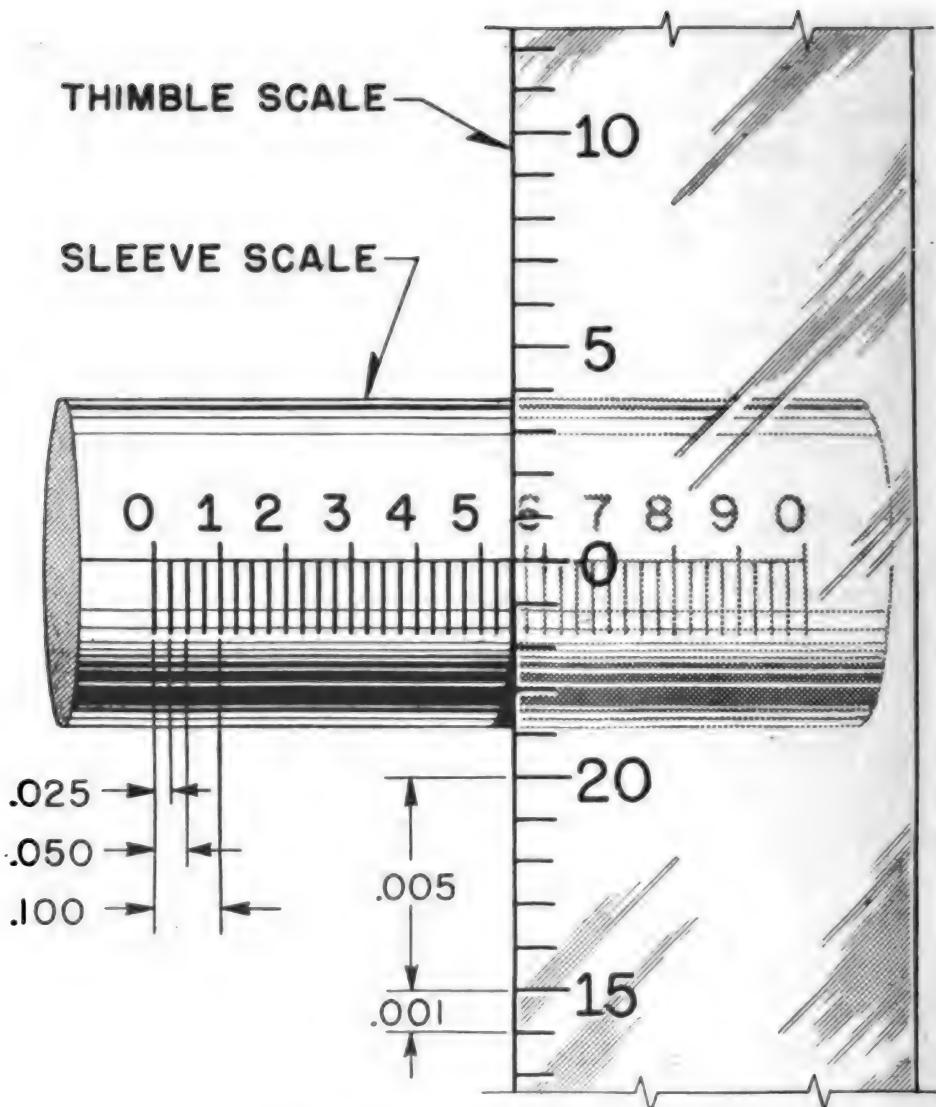


Figure 91.—Micrometer scale.

uated lines. This scale is divided into 25 equal parts, each unit representing  $\frac{1}{25}$  of a turn. And  $\frac{1}{25}$  of .025" is .001". Every fifth line is marked 5, 10, 15, etc.

#### READING THE SCALE

The close-up in figure 92 will aid you in understanding how to take a complete micrometer reading. (Don't guess nor estimate—but read the scales.) Count the units on the thimble scale and add them to the reading on the sleeve scale. The

reading in the figure shows a sleeve reading of .250 with the tenth line on the thimble scale coinciding with the horizontal sleeve line. Number 10 on this

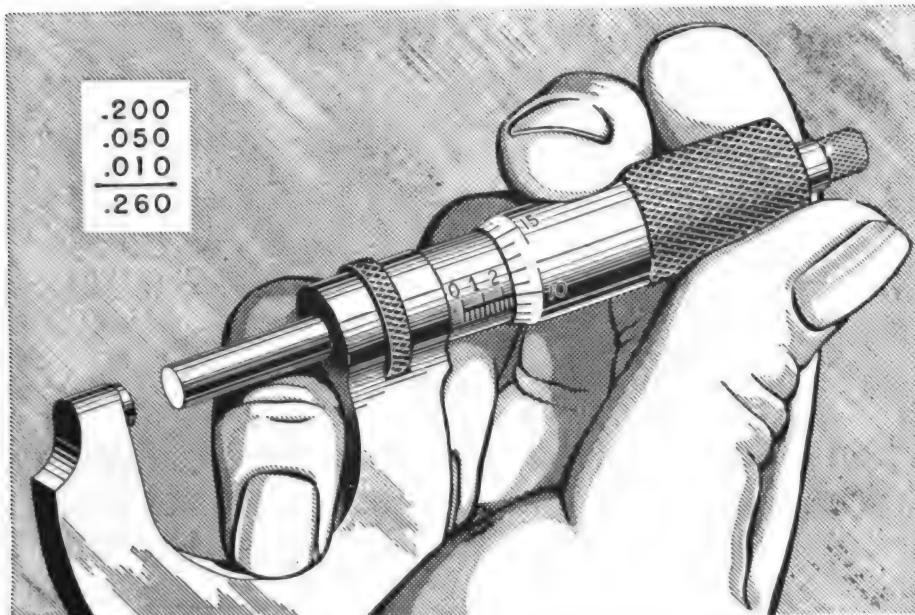


Figure 92.—Micrometer reading.

scale means that the spindle has advanced an additional  $10 \times .001$  or .010. Add this amount to the .250 sleeve reading and the total distance is .260.

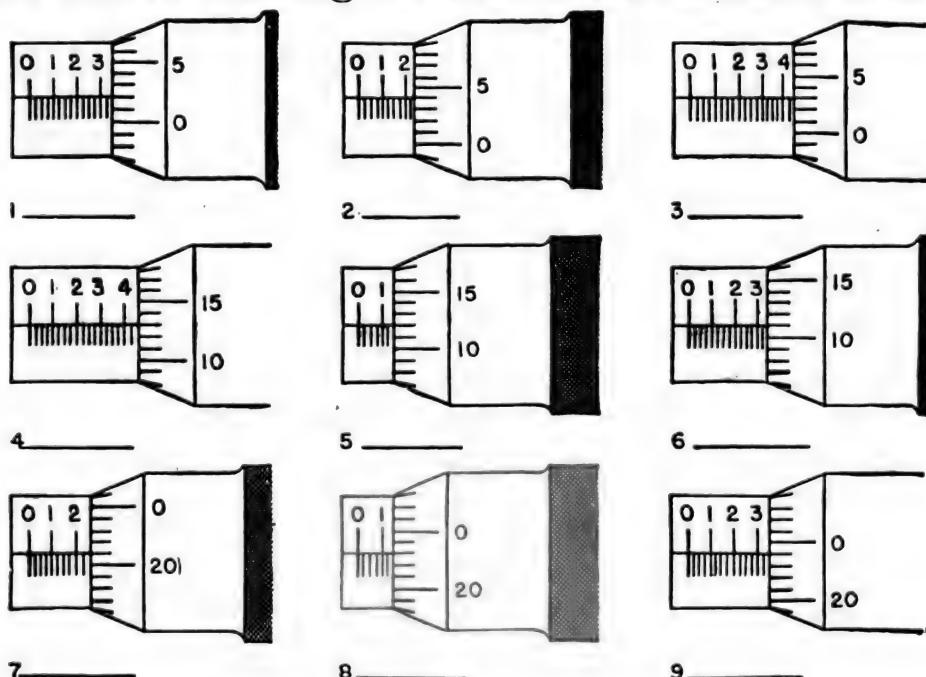


Figure 93.—Micrometer-reading exercises.

## MICROMETER-READING EXERCISES

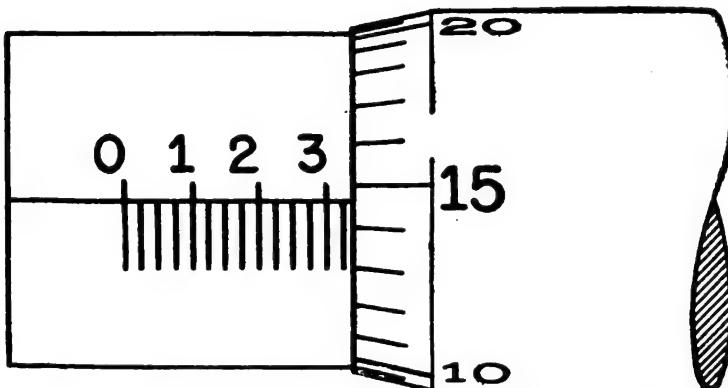
Try to read each of the micrometer settings in figure 93 so that you can be sure of yourself when you begin to use this tool on the job.

Answers for checking—

- |            |            |            |
|------------|------------|------------|
| 1. = 0.327 | 4. = 0.438 | 7. = 0.246 |
| 2. = 0.229 | 5. = 0.137 | 8. = 0.148 |
| 3. = 0.428 | 6. = 0.336 | 9. = 0.349 |

## MAKESHIFT

When you use a regular micrometer you can only read dimensions in the thousandths of an inch. In many instances you will find that the line on



$$\begin{array}{r} .300 \\ .025 \\ .015 \\ \hline .340 \end{array}$$

Figure 94.—The reading on this scale is .340".

the thimble will not coincide with the horizontal line on the sleeve. The additional distance must be guessed roughly or entirely neglected. Look

at figure 94 which shows a sleeve reading of .325. The 15th line on the thimble does not meet the line on the sleeve. If you take the reading on the 14th line, the dimension will be .339. If you take it on the 15th line, the reading will be .340. Use the mark closest to the sleeve for ordinary work.

### THE VERNIER MICROMETER

Many times you will be required to get exceptionally accurate dimensions. When you are, use a ten-thousandth micrometer. This instrument has a third scale known as a vernier, shown in fig-

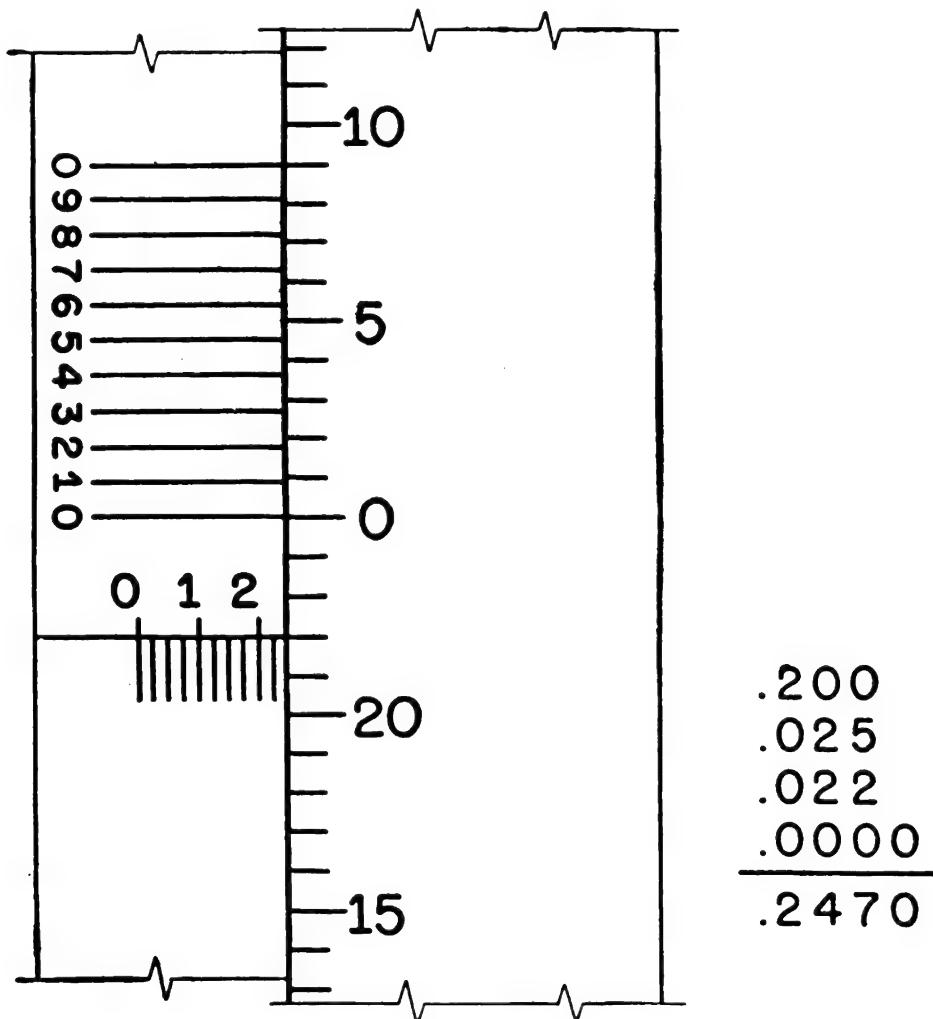
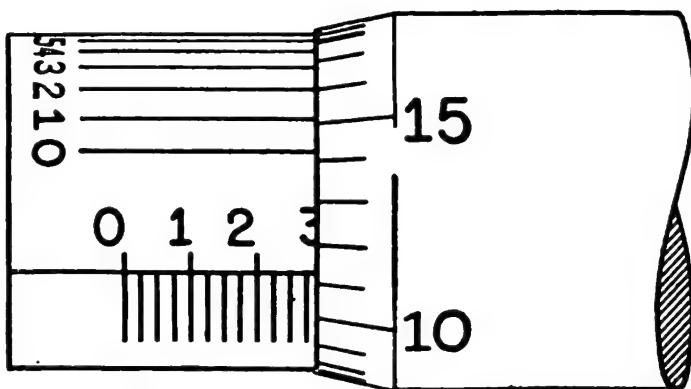


Figure 95.—The vernier scale.

ure 95, that furnishes the fine readings between the lines on the thimble. The ten spaces parallel to the sleeve are equivalent to nine spaces on the thimble. Each unit on the auxiliary scale is equal to .0001".



$$\begin{array}{r}
 .200 \\
 .075 \\
 .011 \\
 \underline{.0002} \\
 .2862
 \end{array}$$

Figure 96.—Sleeve + thimble + vernier scale = .2862.

When a line on the thimble scale does not coincide with the sleeve line, you can determine the additional space beyond the readable thimble mark by finding a thimble mark which coincides with a line on the auxiliary scale. Then add this number to the original reading. See how the second line on the .0001" scale coincides with a line on the thimble scale in figure 96. This means that the "0" on the thimble has been advanced an additional .0002". When you add this to the other readings, the figure will be .286+.0002", or .2862".

## GAGES

You can readily find the size of twist drills, rods, and wires by using a drill gage, such as the one shown in figure 97. To use this gage, insert the drill in the smallest possible hole. The holes are labeled with both the number of the drill and its decimal equivalent. Many drill gages also contain other useful reference material, such as wire size and correct size of drills to use for tap holes.

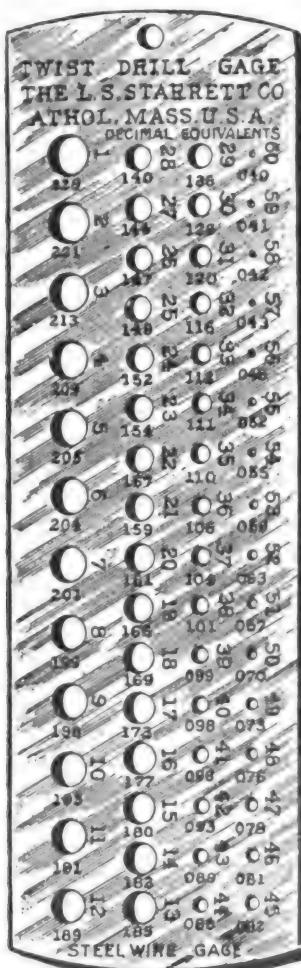


Figure 97.—Drill gage.

The SHEET METAL GAGE shown in figure 98 is nothing more or less than a slotted disk. These slots are numbered in thousandths on one side of the disk and in gage size on the other. Insert the

edge of the metal part to be measured in the smallest possible slot of the disk and you have the correct measurement.

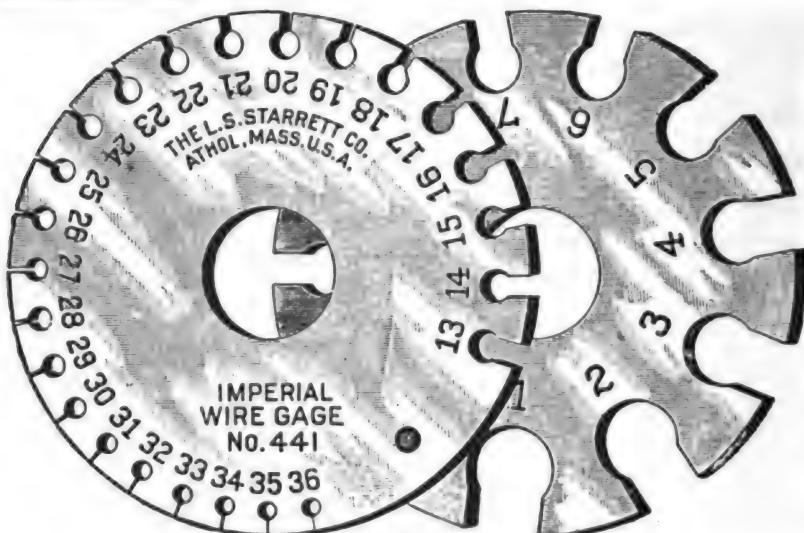


Figure 98.—Sheet metal gage.

You will use a RING GAGE, similar to the one in figure 99, to see if the machine parts conform to specified dimensions. Ring gages are accurately ground, hardened steel rings. The usual type of ring gage consists of two parts, the "Go" part and the "No-Go" part.

Try the two rings over the part you are testing for size. If the size of the part is within the speci-

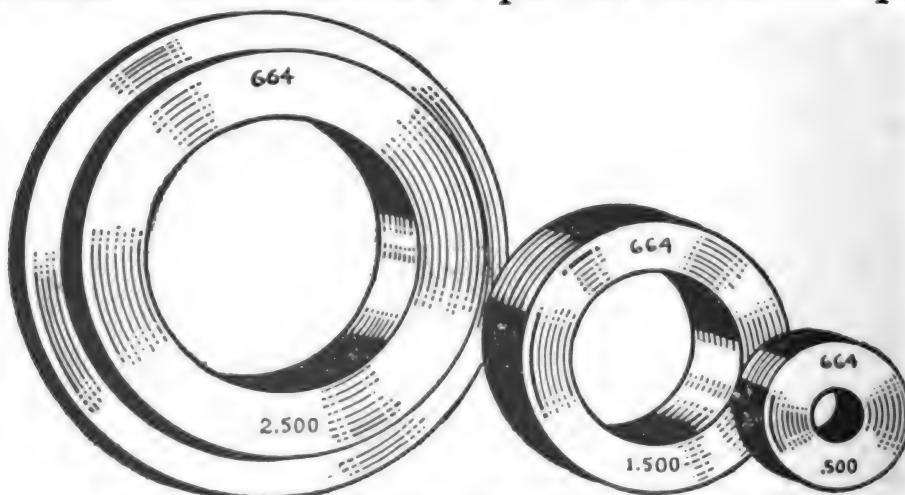


Figure 99.—Ring gage.

fied dimensions, the "Go" part of the gage will fit over the work. You will find it impossible to fit the "No-Go" part over the object.

## MEASURING CLEARANCES, DEPTHS, INSIDE DIAMETERS

Some of the most important measurements you will take are clearances, depths, and inside diameters. Tools for making these measurements include depth gages, inside calipers, inside micrometers, thickness gages, and plug gages.

Notice the difference in the way the legs point on the INSIDE CALIPERS shown in figure 100. Other-

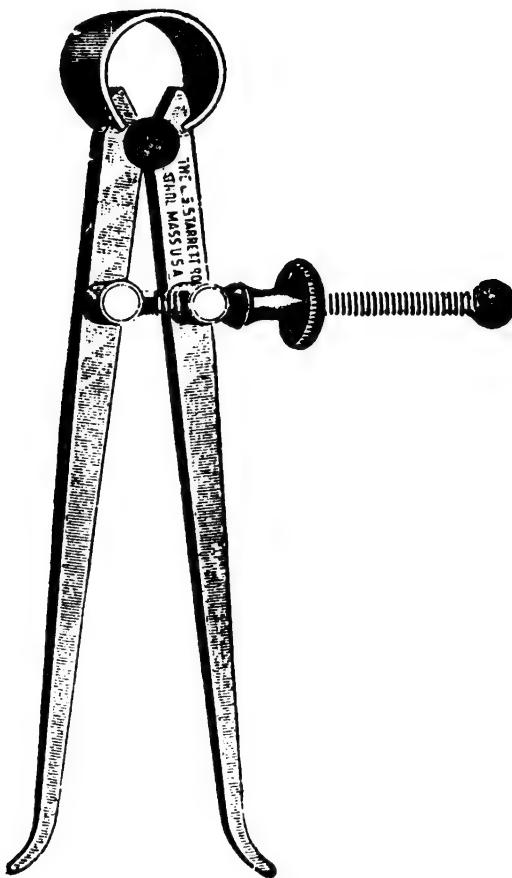


Figure 100.—Inside calipers.

wise, the tools are constructed similarly to outside calipers. You will take inside measurements with these calipers.

The instrument you see in figure 101 is a standard type of TELESCOPING GAGE. Insert the gage into the hole or recess you want measured. Loosen the knurled lock nut and a spring will expand the

plunger to the size of the hole or recess. Tighten the knurl lock nut and remove the instrument. If you want to know the exact size of the hole, use an outside micrometer.

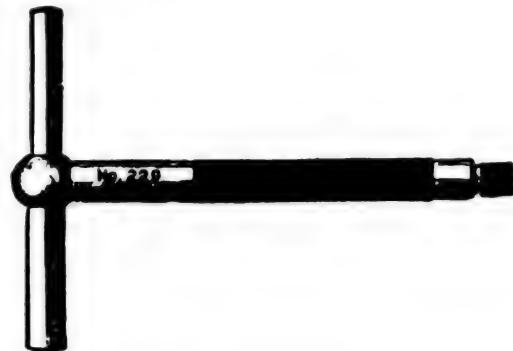


Figure 101.—Telescoping gage.

You can make larger measurements with the extension rods and collars shown with the INSIDE MICROMETER CALIPER in figure 102. This caliper is an adjustable and measuring gage. You will use it for internal linear measurements, such as cylinder and rings, and to set calipers and compare

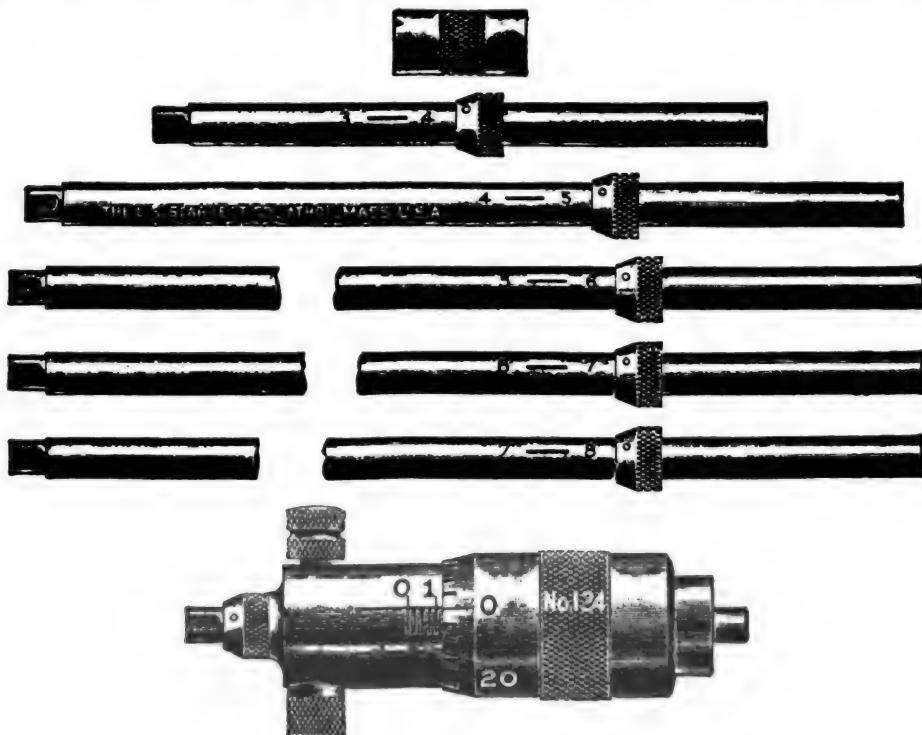


Figure 102.—Inside micrometer calipers.

gages. The measurements are taken over the extreme ends of the calipers, which are hardened and ground as contacts. You can change the distance between the contacts by rotating the sleeve of the micrometer head and the extent of the screw link.

You can use DEPTH GAGES to measure the depth of holes or distance to a shoulder. All are used in the same way, but the method of reading is different in each case. You can use the rule depth gage

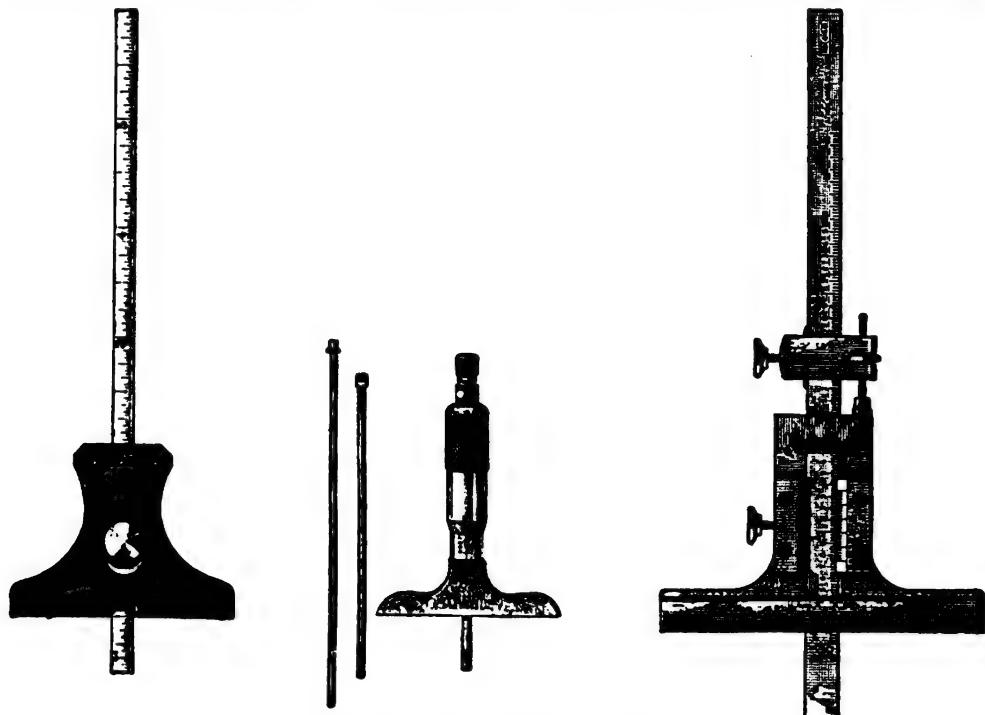


Figure 103.—Depth gages.

for measurements where extreme accuracy is not required. If you want greater accuracy, use any of the other models since their scales are graduated into thousands of an inch. See figure 103 for some examples of depth gages.

When you take inside measurements, you will use a DIAL INDICATOR of the type shown in figure 104. You can measure holes of various sizes by using the extension rods. These instruments are particularly valuable in determining variations in cylinder diameters.

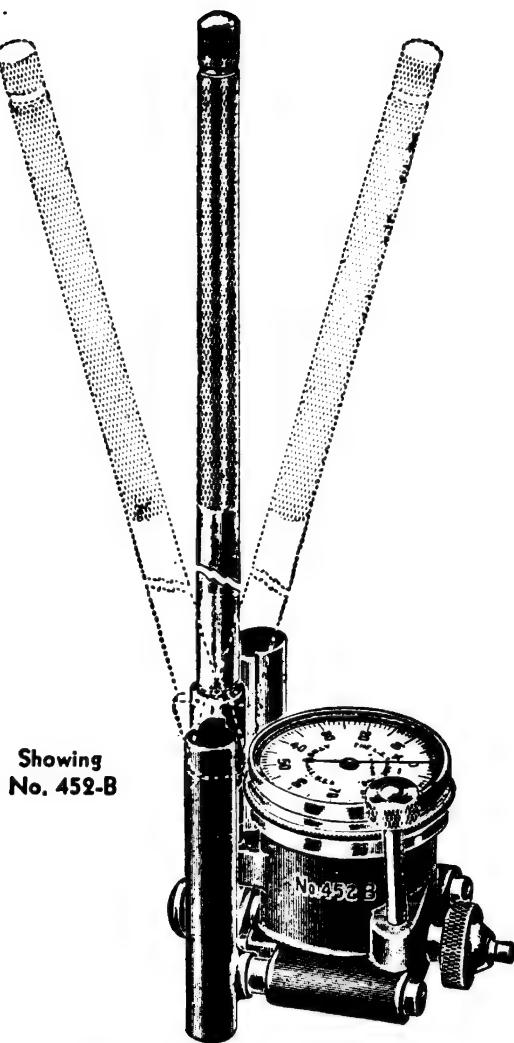


Figure 104.—Dial indicator.

**PLUG GAGES** consist of accurately ground, hardened steel gages for the measurement of inside diameters. The usual type of plug gage is called the "Go-NoGo" gage. One end of the gage is ground to the minimum diameter allowed in the hole. The other end is ground to the maximum allowed diameter. Try to insert both ends of the gage into the hole you are measuring. The "Go" end should enter the hole, the "No Go" end should not enter. Look at the illustration of this type in figure 105.

The **THICKNESS GAGE** shown in figure 106 is an indispensable tool. This tool, which is often called a "feeler" gage, consists of a number of blades that

can be folded into a hollow handle. Each of the blades is ground to an exact thickness, marked in thousandths of an inch on the blade. When you use this tool, insert various blades or combinations of blades between two surfaces until a snug fit is obtained. The thickness of the blade or the total thickness of ALL THE BLADES USED is the measurement between the surfaces. With the tool shown in figure 106, you could measure clearances or gaps ranging from .0015" to .0615".

It requires a great deal of experience to be able to take an exact measurement with a thickness gage. Accuracy depends to a large extent upon your ability to determine by feel when there is the correct tension on the blade. Get accustomed to the feel of this gage by measuring objects of known clearance. Compare these measurements with those taken by an experienced technician.

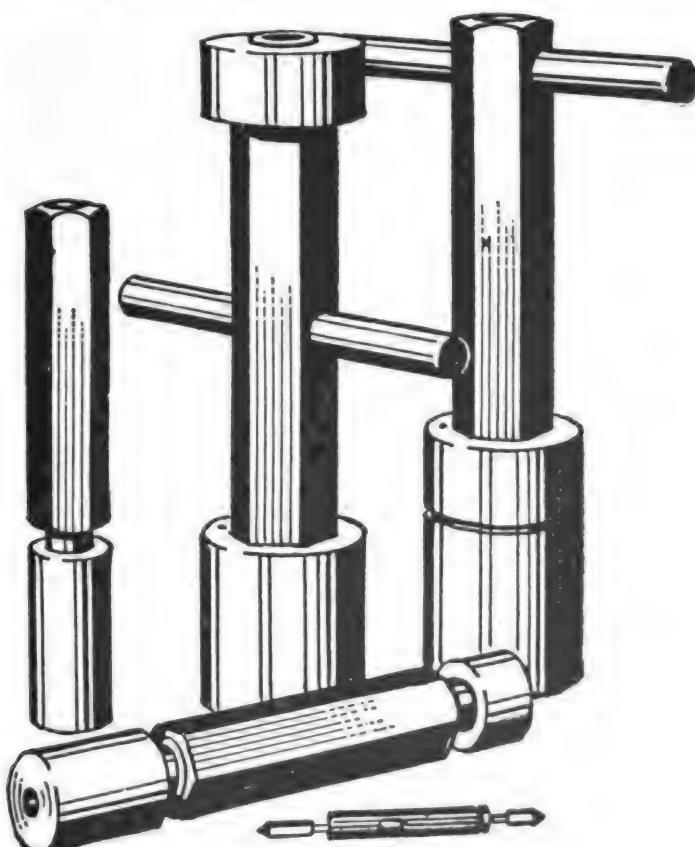


Figure 105.—Plug gages.

Thickness gages must be kept free from grease. If there is any foreign matter on the blades, it will be impossible to get a correct reading. If you try to force the blades into openings too small for them, they may be bent or kinked. You will notice that the thin blades of the thickness gage in figure 106 are protected when not in use by the heavy blades on the outside. Keep the gage closed except when you are measuring with it. If you are not planning to use the tool for a considerable length of

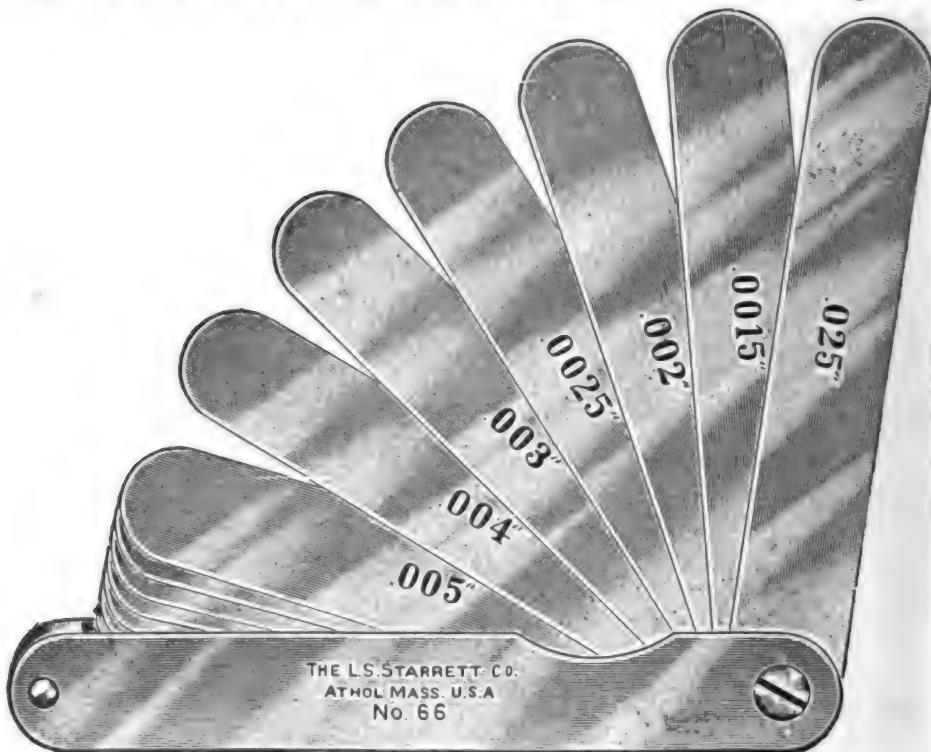


Figure 106.—Thickness gages.

time, the blades should be protected with a coating of light oil. Wipe off the oil before using the blades again.

#### MEASURING ANGLES

Frequently you will have to determine angles between parts or units of aircraft. In layout work, it is also sometimes necessary to measure angles. The tools most frequently used for measuring angles are squares, the combination set, angle gages, and levels.

Convenient measuring tools, called **SQUARES** are shown in figure 107. The four pictured here are the steel square, the double square, the try-square,

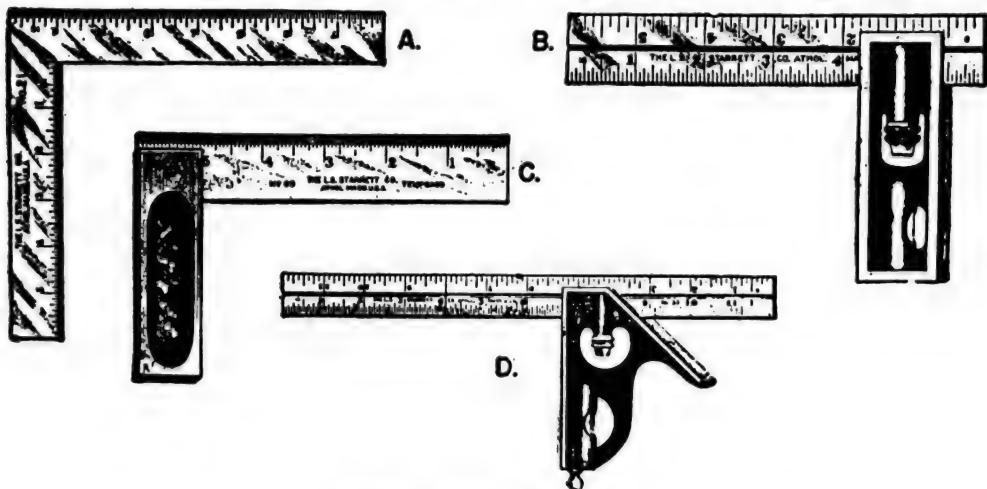


Figure 107.—Squares.

A. Steel square.  
B. Double square.

C. Try-square.  
D. Combination square.

and the combination square. This last square consists of a graduated steel rule with an accurately machined head. The two edges of the head provide for measurements of 45 and 90 degrees, respectively.

**COMBINATION SETS** are necessary when you have to measure a variety of angles. They consist of a steel rule and three heads. The square head is the

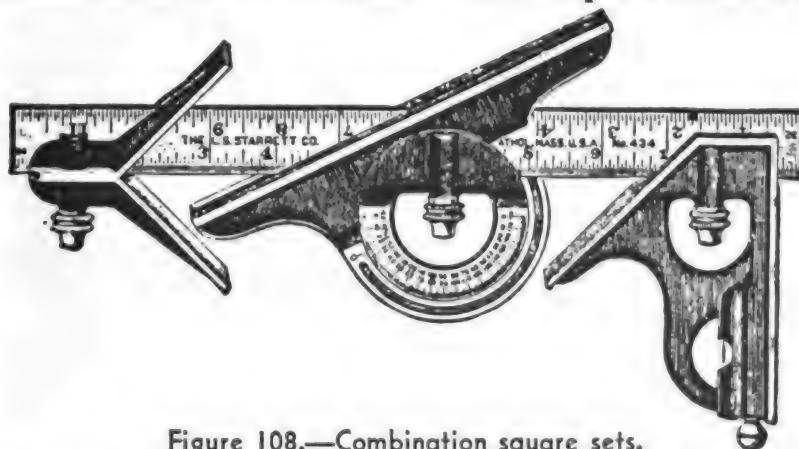


Figure 108.—Combination square sets.

same as that provided with the combination square. This combination set, shown in figure 108, also has a protractor head for the measurement of any de-

sired angle, and a center head to center round stock. You may set the protractor head at any desired angle by loosening a clamp screw and turning the head.

ANGLE GAGES are made up of a number of pieces of metal ground to accurate angles. Notice the one shown in figure 109. Angle gages are used instead of a protractor where it is necessary to measure the same angles frequently.

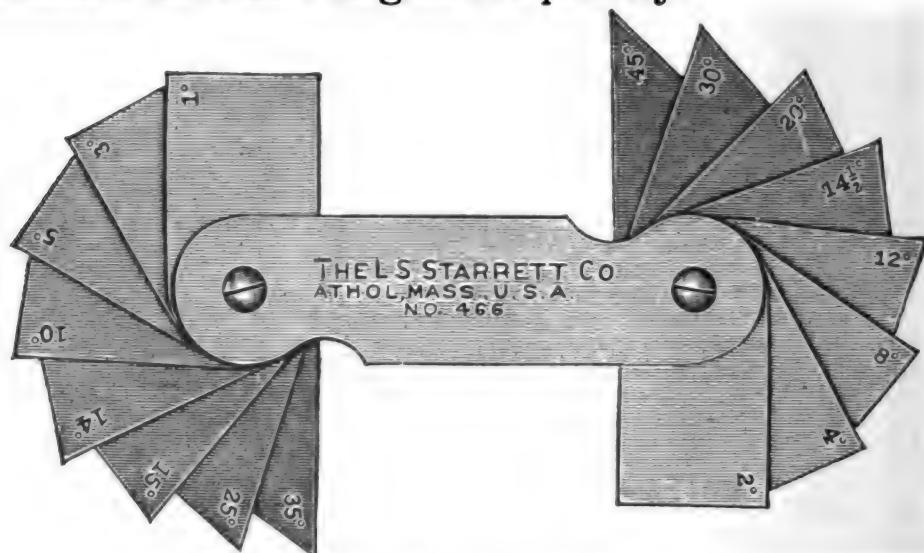


Figure 109.—Angle gages.

You will use LEVELS, frequently called spirit levels, in setting up aircraft and checking alignment. The levels are generally used in conjunction with a board cut to the desired angle or are an integral part of a protractor or inclinometer. A level consists of a glass tube containing a fluid and an air bubble. Figure 110 is an illustration of a

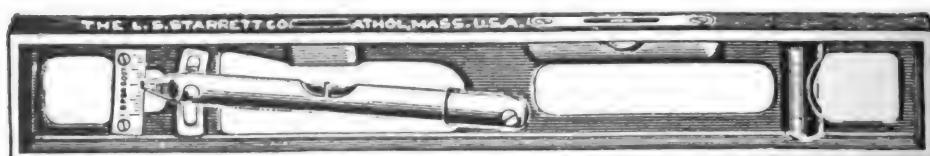


Figure 110.—A level.

level. When you hold this tube exactly level, the air bubble is exactly centered in the tube. When not in a level position, the bubble moves to the high end of the tube.

## SCREW PITCH GAGES

You can determine the pitch of a screw thread by comparing it with the standards provided by a screw pitch gage. Gages similar to that shown in

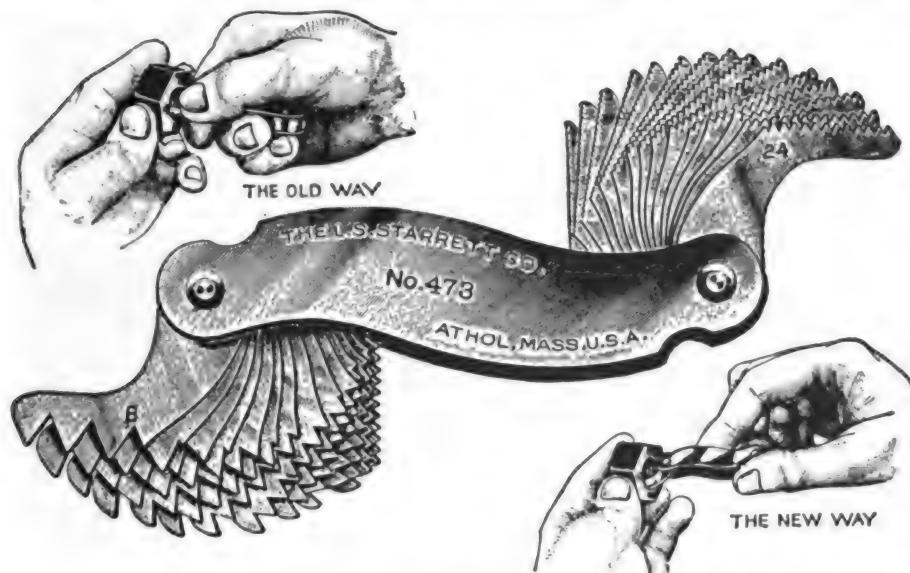


Figure 111.—Screw pitch gage.

figure 111 consist of a number of leaves attached to a handle. The leaves are accurately machined on one edge to conform to the standards of the

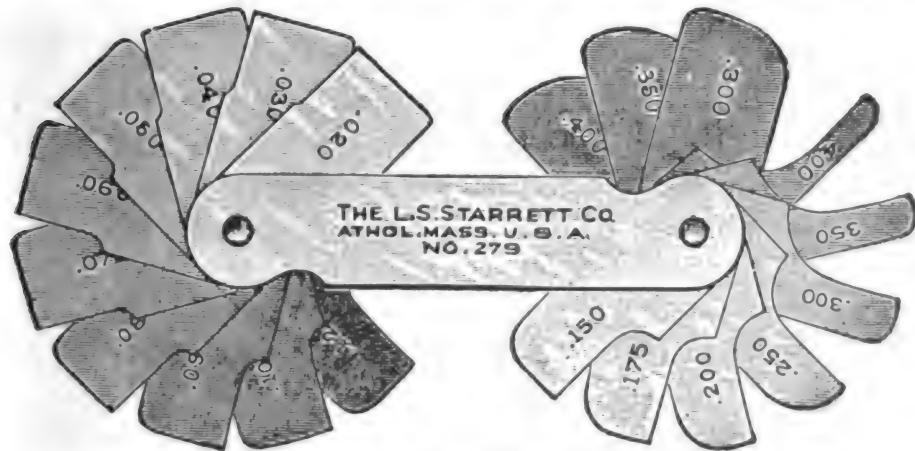


Figure 112.—Radius gage.

cross-sectional shape of the screw threads they are designed to measure. Place the screw pitch gage into the threads to be measured so that the teeth

on the gage line up with the threads. The teeth on the gage will line up exactly with correctly made screw threads of the same pitch.

RADIUS GAGES—see figure 112—are used for measuring fillets or radii in machine or layout work.



## CHAPTER 9

### ABRASIVES

#### THE BRUSH-OFF

Technically, abrasives are materials—not hand tools. But their proper selection and use is of so much importance that they rate space in a hand-tool book. Their job is to give metal and wood the brush-off. That is, they rub off or wear away by friction any surface that needs a fine finish.

Modern abrasives are made of five different cutting minerals. These are aluminum oxide, silicon carbide, emery, garnet, and flint with various backings of paper, cloth, or a combination of paper and cloth. This material, in turn, is made into disks, wheels, rolls, sheets, belts, bands, sleeves, and so on. Each mineral has a specific part in grinding, polishing, or finishing and, when used as recommended, proves economical and efficient as a time and material saver.

Abrasives are available in two types of coating—OPEN COATING and CLOSED COATING. Open coating has the abrasive particles spaced apart from one

another. This offers less opportunity for the surface to become filled when you are grinding or polishing soft materials such as solder, soft metals, and finishes.

CLOSED COATING is a close union of the abrasive particles for the purpose of providing a hard, fast cutting surface. This type of coating is best for grinding "tough" jobs such as cutting down arc welds, acetylene welds, and for polishing and finishing metal.

### ALUMINUM OXIDE

This is used for grinding, polishing, and finishing metal surfaces of all kinds. It is also used for wood sanding along with certain metal-sanding operations.

Aluminum oxide WHEELS are used generally for materials of high tensile strength where the material is neither very brittle nor easily penetrated, such as carbon, alloy and high-speed steels, and wrought iron and tough bronzes.

### SILICON CARBIDE

Silicon carbide is used for grinding and polishing materials of low tensile strength, such as soft brasses, aluminum, glass and marble, and also on such easily penetrated materials as wood and leather. Silicon carbide cloth and paper are employed for wet sanding lacquer, synthetic enamel, or varnish finishes. Both cloth and paper are also good for removing old paint and sanding new and old floors. Put the final polish on stainless steel with a silicon carbide belt.

Here is a chart showing the factors affecting the selection of the abrasives.

Physical prop- erties of the material to be ground	Use aluminum oxide grinding wheels for materials of high tensile strength.	Carbon steels. Alloy steels. High-speed steels. Annealed malleable iron. Wrought iron. Tough bronzes. Tungsten.
	Use silicon carbide grinding wheels for materials of low tensile strength.	Gray iron. Chilled iron. Brass and bronze. Aluminum and copper. Marble. Granite. Pearl. Rubber. Leather.

#### ADDED NOTES

**EMERY CLOTH** is used extensively to clean and polish metal parts. It consists of finely ground particles of emery cemented to a tough cloth backing, and ranges from fine #000 to the coarse #3. Be careful that the grade you use is not too coarse when you polish metal parts. This abrasive often cuts faster than you expect it to, and a scratched or uneven surface may result.

If you want a higher polish than can ordinarily be obtained by a dry emery cloth, use a lubricant such as engine oil or kerosene. **CROCUS CLOTH** is used to give a high polish on steel surfaces. This is also an emery base abrasive, but is much finer than emery cloth.

Another material that is used frequently to obtain a high polish is **GROUND PUMICE STONE**. This comes in powdered form and can be used either plain or with the addition of a few drops of water or oil. Pumice makes an excellent polishing compound, but it is often less convenient to use than crocus cloth.

**GARNET PAPER** and cloth is useful for sanding

wood surfaces to remove stock and finish the surface. Sandpaper is the most common type of abrasive used on woodwork but is not as satisfactory as garnet paper. FLINT PAPER is used for hand sanding wood surfaces of all kinds and for maintenance work.

Water, water with light oils or sulphonated oil, and water emulsions are used as a lubricant when METAL is being sanded. Wet sanding keeps the parts being finished COOL and at the same time prevents loading or filling of the abrasive belt.

### ALUMINUM FINISHING

The free-cutting aluminum alloys may be ground, polished, or buffed readily. Experience with aluminum indicates that good results are obtained with silicon carbide wheels.

After a grinding wheel has been selected, there are three factors which affect the quality of a finish, namely, wheel speed, work speed, and grinding compound. Wheel speeds of about 6,000 feet per minute give good results. A solution of soluble cutting oil and water works well as a grinding compound. Remember to strain the fine grindings of aluminum from the compound before re-using it. If you do not strain it, these fine grindings may put deep scratches on the finished surface.

The soft alloys cause the grinding wheel to clog and require generous use of a grease stick. What's more, special care must be taken in grinding castings and wrought alloy products that have been heat-treated. Their greater resistance to cutting generates a considerable amount of heat, which in turn may cause warping and render the maintenance of dimensions difficult.

NEVER USE STEEL WOOL ON ALUMINUM. Reason—it forms corrosion when the airplanes are around salt water.

**How Well Do You Know—**

# **HAND TOOLS**



# QUIZ

## CHAPTER I

### GENERAL PURPOSE TOOLS

1. If a tool gets dirty or rusty, what should you do to it?
2. Why should you use hammers sparingly when working on aircraft?
3. If the steel wedge in the end of your hammer handle comes out, what should you do? Why?
4. If the blade of your screw driver does not make a good fit in the screw slot, what trouble will you run into?
5. On what general type of screw driver should you use—
  - (a) Wrenches?
  - (b) Pliers?
6. Why shouldn't you ever use pliers on nuts?
7. (a) What kind of pliers have their cutting jaws at an angle?  
(b) Mention three jobs for which these pliers are especially useful.

## CHAPTER 2

### MORE GENERAL PURPOSE TOOLS

1. Why is high-quality steel used to make aircraft wrenches?
2. (a) The combination wrench combines the advantages of two other wrenches. What are those wrenches?  
(b) What kind of wrench has numerous handles and accessories which make it very adaptable?  
(c) What kind of wrench is designed with hooks, lugs, or pins?  
(d) What general type of wrench sometimes has a handle to measure the amount of pull put on the wrench? What is the wrench called when it has such a handle?

- (e) What kind of wrench is designed with a 12-notch opening that fits over and surrounds the bolt head or nut?
  - (f) What are the advantages of such a fit?
  - (g) What is the basic difference between an ordinary open-end and an adjustable wrench?
3. (a) What is "flopping"?
  - (b) What is the advantage of this procedure?
4. What two punches should you use to drive a pin out of a hole? Name them in the order in which they should be used.
  5. If you had to move or shift two parts into position with a hole in one centered directly under a hole in the other, what punch would help you?
  6. (a) What punch is used to mark the location of holes to be drilled?
  - (b) If the location is not punched, what will probably happen when you start drilling?

## CHAPTER 3

### SHAPING AND CUTTING TOOLS

1. What kinds of metal can you cut with a cold chisel?
2. (a) Why should you avoid cutting sheet or plate metal with a cold chisel whenever possible?  
(b) When you have to cut thin sheet metal with a cold chisel, what kind should you use?  
(c) What kind should you use when the sheet metal is thick?  
(d) What kind should you use to draw back a drill that has "run out"? What are two other common uses for this kind of chisel?  
(e) Mention another type of cold chisel.
3. (a) In which hand should you ordinarily hold a chisel?  
(b) What part of the chisel should you watch as you work?

- (o) What determines the depth of the cut your chisel makes?
4. Describe the correct way to cut sheet or plate metal with a cold chisel.
5. Mention a rule for chiseling—  
(a) Steel.  
(b) Cast iron.
6. (a) What do you use to sharpen a chisel?  
(b) To what angle should you sharpen the cutting edge?  
(c) Why should you dip the cutting end in water occasionally as you sharpen the chisel?
7. (a) What is meant by the "set" of a saw?  
(b) Name and describe one kind of hacksaw set.  
(c) What is meant by "pitch"?
8. What characteristics of a hacksaw are most important when you are selecting one for a particular job?
9. (a) About how fast should you saw metal of average hardness?  
(b) Why should you saw harder metals slower?  
(c) Explain when and how much you should bear down on the hacksaw.  
(d) How should you test metal before you use a hacksaw on it?
10. Why is a pilot drill used with a circular hole saw?
11. (a) What is the difference between single-cut and double-cut files?  
(b) If a file is graded as second-cut, by what characteristic has it been classified? What are the other five grades of files within this classification?  
(c) What are the six grades of files according to SHAPE?
12. (a) What kind of file should be used for "draw-filing"?  
(b) How should it be moved, in relation to the work?  
(c) What is the purpose of draw-filing?
13. (a) How do you break in a file?  
(b) How are you likely to damage the material you

- work on if you use a new file before it has been broken in? What is this kind of damage called?
14. (a) Why should you always stop a cut about  $\frac{1}{4}$ " before the ends of hand-snip blades have been reached?  
(b) How can you obtain maximum leverage with hand snips on heavy metal?  
What is another reason for observing this rule?
15. What instrument do you use to dress sheet metal to size?

## CHAPTER 4

### SOLDERING TOOLS

1. (a) What is "soldering"?  
(b) What is "solder"?
2. (a) What is the purpose of the soldering copper?  
(b) By what means is it heated?
3. (a) When solder is applied without a soldering copper, how is it melted? What tool usually supplies the heat?  
(b) How do you operate this tool?

## CHAPTER 5

### DRILLING AND REAMING TOOLS

1. (a) What name is given to the extreme tip end of the twist drill?  
(b) What is the entire cone-shaped surface at the cutting end called?  
(c) What are the other five points involved in grinding?
2. (a) To what angle should the lips (cutting edges) of the drill be ground?  
(b) What are two common mistakes you must be careful to avoid in grinding the lips?

3. (a) What are the "flutes" of a twist drill?  
(b) What name is given to the angle of the flutes in relation to the work?  
(c) How large should this angle be? Why is it dangerous for this angle to be too small?
4. What is the basic difference between working with hand drills and with electric drills?
5. What is the difference between the sizes of holes you can drill in steel with an ordinary hand drill and with an electric drill?
6. When you use an electric drill—  
(a) How do you start the hole?  
(b) When do you turn the motor on?  
(c) When do you turn the motor off?
7. What are the rules for safe use and care of electric drills?
8. (a) After you have drilled a hole, what tool can you use to enlarge it?  
(b) What else can you use this tool for?  
(c) What are its three parts?  
(d) Why can you turn this tool in only one direction inside a hole?  
(e) Why is this tool likely to chip if it is not used and stored very carefully?
9. What are countersinks used for?

## CHAPTER 6

### THREAD-CUTTING TOOLS

1. (a) What is the basic difference between threads in the N. C. and N. F. series?  
(b) What do the initials N. C. and N. F. stand for?  
(c) Which series is generally used in aircraft work? Why?  
(d) What are the initials of the standard series including threads which are neither N. C. nor N. F.?

2. What tool would you use to cut the threads of a—
  - (a) Threaded plug?
  - (b) Threaded hole?
3. How do you know what size drill to use in drilling a hole that is to be threaded?
4. (a) To position a screw extractor, should you strike it hard? Why?  
(b) What other tool(s) do you use with the screw extractor?

## CHAPTER 7

### TUBING FABRICATING TOOLS

1. (a) How is tube cutting done by a tube cutter better than that done by a hacksaw?  
(b) What is new about the tube cutters now in use?
2. What two tools do you need for flaring?
3. What are three common defects in flares?
4. (a) What is the simplest way of bending tubing without kinking or flattening it?  
(b) Name a tool you can use for this same job.

## CHAPTER 8

### MEASURING TOOLS

1. (a) What is the most common type of tool used for measuring length?  
(b) What tool can be used for transferring lengths from one piece of work to another, as well as for scribing circles and arcs?  
(c) What tool used for measuring length has to be wound back into its case with a crank?
2. (a) Mention several tools used for measuring thickness and outside diameters.  
(b) Which of these should be used with a rule (or gage)?  
(c) Which works on the "Go—No Go" principle?

3. (a) What kind of caliper can measure outside diameters and length only to .001 inch?  
(b) What distance along the sleeve scale is represented by the space between any two graduations on the thimble scale of this caliper?  
(c) When do you use the thimble scale?
4. (a) What distance may you have to estimate or disregard, in using the instrument described in No. 3 above?  
(b) With what instrument can you measure such a distance precisely?  
(c) How is this instrument designed for such measurement?
5. What is a sheet-metal gage?
6. (a) What tools are useful for measuring hole depths?  
(b) What is the best tool for measuring clearance? Describe its construction briefly.  
(c) What tool for measuring outside diameters works on the "Go—No Go" principle?  
(d) What other tools for measuring depth, inside diameter, or clearance are discussed in this chapter?
7. (a) What tool is useful for measuring a variety of angles?  
(b) What tool is useful for measuring and remeasuring the same angles frequently?  
(c) What kind of tool will measure  $90^\circ$ , or  $45^\circ$  and  $90^\circ$ , angles only?
8. How do you determine the pitch of a screw thread by means of a screw pitch gage?

## CHAPTER 9

### ABRASIVES

1. What are abrasives used for?
2. (a) What physical characteristic of the material you grind do you consider when selecting the abrasive?

- (b) What kind of abrasive should be used on materials having high, and low, degrees of this characteristic?
  - (c) Mention a few materials having high, and low, degrees of this characteristic.
3. What materials are used for polishing metals?

# **ANSWERS TO QUIZ**

## **CHAPTER 1**

### **GENERAL PURPOSE TOOLS**

1. Clean it and give it a coating of light oil.
2. Aircraft metals are soft.
3. Replace it before using the hammer again. It wedges the hammer handle in the head so the head cannot fly off.
4. Screw slot may be burred.  
Blade tip may be damaged.  
It will be hard to keep the screw driver in the slot.
5. (a) Heavy-duty screw drivers with square shanks.  
(b) NO screw drivers.
6. Pliers damage the "flats" of the nut.
7. (a) Diagonal.  
(b) Cutting soft wire.  
Removing or applying safety wire.  
Removing or replacing cotter pins.

## **CHAPTER 2**

### **MORE GENERAL PURPOSE TOOLS**

1. Because it is light as well as strong.
2. (a) Open-end wrench and box wrench.  
(b) Socket wrench.  
(c) Spanner wrench.  
(d) Socket wrench. Torque wrench.  
(e) Box wrench.  
(f) The wrench will not slip off the bolt head or nut.  
(g) Both jaws of the ordinary open-end wrench are fixed (stationary), whereas one jaw of an adjustable wrench is movable.

3. (a) Turning the wrench over, so that the other face is down, after each stroke.  
(b) It makes it possible to turn a nut continuously, when swinging space is limited.
4. Starting (Drift) punch.  
Pin punch.
5. Alining punch.
6. (a) Center punch.  
(b) The drill will "wander," or move all around the piece, and you will lose control of the exact location of the hole.

## CHAPTER 3

### SHAPING AND CUTTING TOOLS

1. Any metal softer than the chisel, or any metal that can be cut with a file.
2. (a) The metal will invariably stretch.  
(b) Flat.  
(c) Cape.  
(d) Round nose. Cut round or semicircular grooves and chip inside corners.  
(e) Diamond point.
3. (a) Left.  
(b) Cutting edge.  
(c) The angle at which the chisel is held in relation to the work.
4. Check your answer against page 38.
5. (a) Lubricate the chisel point with light machine oil to make it cut faster and drive more easily.  
(b) Chip from the edges of the work toward the center, to avoid breaking off corners.
6. (a) Emery wheel or ordinary coarse grinding wheel.  
(b) Approximately  $60^{\circ}$ .  
(c) To avoid overheating the chisel and changing the temper of the steel.

7. (a) How much the teeth are pushed out in opposite directions from the sides of the blade.  
(b) Check your answer against pages 42, 43.  
(c) The number of teeth per inch.
8. All-hard or flexible blade.  
Pitch.
  9. (a) 40–50 strokes per minute.  
(b) To avoid damaging the saw by overheating.  
(c) On forward (cutting) strokes, use just enough steady pressure to keep the saw cutting.  
When the work is cut nearly through, use slightly less pressure. On return strokes, relieve the pressure. Lift the saw from the work.  
(d) Try to nick it with the very front or rear teeth of a saw, or the tip of a file, to see whether it can be cut.
  10. To hold the saw steady as it cuts.
  11. (a) Single-cut files have single rows of parallel teeth across their faces, whereas double-cut files have rows of teeth crossing each other.  
(b) The spacing and size of its teeth. Rough, coarse, bastard, smooth, dead-smooth.  
(c) Mill, flat, round, half-round, hand, triangular.
  12. (a) Single-cut, smooth.  
(b) Sidewise along the work.  
(c) To produce a very smooth surface.
  13. (a) Use it first on a wide surface of brass, bronze, or smooth cast iron. Apply only light pressure during the first few strokes.  
(b) The new file is likely to clog up with particles from the work, and scratch the material being filed. Pinning.
  14. (a) If the points of the snips come together, they will tear the metal.  
(b) Use only the rear portion of the blades. It avoids springing the blades.
  15. File.

## CHAPTER 4

### SOLDERING TOOLS

1. (a) The joining of metal parts by a metal called solder.
- (b) An alloy of metals such as lead and tin, having a melting point lower than either of its components and lower than that of the metals to be joined.
2. (a) To transmit heat.
- (b) By blowtorch, gas flame, or electricity.
3. (a) Heat is applied directly to the metal surfaces to be joined, and these heated surfaces melt the solder. A gasoline blowtorch usually supplies the heat.
- (b) Check your answer against pages 70-72.

## CHAPTER 5

### DRILLING AND REAMING TOOLS

1. (a) Dead center.
- (b) Point.
- (c) Heel, lip clearance angle, margin, body clearance, web.
2. (a)  $59^\circ$ .
- (b) Grinding the cutting edges to different angles.  
Grinding the cutting edges to equal angles but different lengths.
3. (a) Spiral grooves formed along the sides of the drill.
- (b) Rake angle.
- (c) About  $22^\circ$ - $30^\circ$ . The cutting edge will then be so thin that it may break under the strain of the work.
4. In drilling by hand the operator must furnish the turning power, whereas the power for turning the electric drill is furnished by the drill itself.
5. Most hand drills can make holes up to  $\frac{1}{4}$ " in diameter, whereas electric drills used in aviation work can drill holes up to  $\frac{1}{2}$ " in diameter.

6. (a) With a center punch.
- (b) Before inserting the twist drill point into the punch mark.
- (c) After withdrawing the drill point from the hole.
7. Check your answer against pages 81, 82 and 86, 87.
8. (a) Reamer.
- (b) Truing holes.
- (c) Body, shank, blades.
- (d) Turning it in any direction except the cutting direction will chip or dull the blades.
- (e) Its hardened steel blades are very brittle.
9. Beveling the edges of drilled holes.

## CHAPTER 6

### THREAD-CUTTING TOOLS

1. (a) Pitch: N. C. threads have fewer threads per inch than N. F. threads have.
- (b) National Coarse and National Fine.
- (c) N. F. Parts must be held securely in place.
- (d) N. S.
2. (a) Die.
- (b) Tap.
3. The drill size should be equal to the diameter of the tap minus one and one-half times the depth of the thread.
4. (a) No. It is brittle.
- (b) Wrench.  
Hammer.

## CHAPTER 7

### TUBING FABRICATING TOOLS

1. (a) It cuts perfectly square ends.
- (b) They have specially processed cutting wheels which will cut carbon and stainless steel tubing as well as copper, brass, and aluminum alloy.
2. Combination flaring tool.  
Hammer.

3. Flares too long, too short, or uneven.
4. (a) Slip a spiral coil of steel wire around the tubing, and form the proper curvature with your hands around the coil.  
(b) Parker hand tube bender.

## CHAPTER 8

### MEASURING TOOLS

1. (a) Steel rule.  
(b) Dividers.  
(c) Flexible steel tape.
2. (a) Caliper rule.                      Drill gage.  
    Outside caliper.                      Sheet-metal gage.  
    Micrometer caliper.                 Ring gage.  
(b) Outside caliper.  
(c) Ring gage.
3. (a) Micrometer caliper.  
(b) .001".  
(c) When the edge of the thimble falls BETWEEN two graduated lines on the sleeve scale.
4. (a) Any distance represented by a space between a graduation on the thimble scale and the horizontal line on the sleeve.  
(b) Vernier micrometer.  
(c) It has a third scale (Vernier scale) on the sleeve, parallel to the horizontal line on the sleeve and graduated in 10 units, each of which represents .0001". It is used for measuring distances between the lines on the thimble scale.
5. A slotted disk, numbered in thousandths on one side and in gage size on the other, for measuring metal parts.
6. (a) Depth gages.  
   Rule depth gages.  
(b) Thickness gage. It consists of a number of blades, of varying thickness, that can be fitted into a hollow handle.

- (c) Plug gage.
  - (d) Inside caliper.
    - Inside micrometer caliper.
    - Dial indicator.
7. (a) Protractor. (Combination set.)
  - (b) Angle gage.
  - (c) Square.
8. Place the screw pitch gage into the threads to be measured so that the teeth on the gage line up with the threads. The teeth on the gage will line up exactly with correctly made screw threads of the same pitch.

## CHAPTER 9

### ABRASIVES

1. To rub off or wear away (by friction) any surface that needs a fine finish.
2. (a) Tensile strength.
  - (b) High tensile strength: Aluminum oxide grinding wheel.
  - Low tensile strength: Silicon carbide grinding wheel.
  - (c) Check your answer against page 135.
3. Emery cloth.
  - Crocus cloth.
  - Ground pumice stone.





